Knowledge.

With which is incorporated Hardwicke's Science Gossip and the Illustrated Scientific News.

A Monthly Record of Science.

Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

AUGUST, 1910.

ON THE STUDY OF DOUBLE STARS BY AMATEUR OBSERVERS.

By G. F. CHAMBERS, F.R.A.S.

WHAT CONSTITUTES A DOUBLE STAR?

THIS is a question more easily asked than answered. Opinions and practice have widely differed. In the earlier days of double star work, stars were labelled "double" at distances which are now tacitly repudiated; Struve in the earlier stages of his career, following W. Herschel, enrolled as "doubles," stars at distances which he himself eventually ignored: and in forming his great *Catalogue* he expunged from his provisional lists all stars whose distance exceeded 32″. O. Stone was still more eclectic. He accepted no stars more widely separated than 16″. O. Stone rejected pairs whose distance apart exceeded 32″ where the magnitude of the principal star was less than 8. If the magnitude was less than 9 he further reduced his 32″ limit to 16″, unless the pair were embraced by a certain formula devised by himself, which I deem it unnecessary to give.

Innes compiled his *Reference Catalogue* more or less on the following principles of inclusion and exclusion. He made the limit of separation to be accepted to depend upon the magnitude of the principal star according to a sliding scale exhibited in the following table:—

Magnitude of Star A.	Limit of Separation.	Magnitude of Star A.	Limit of Separation.
1	30″	6	7″
2	25	7	5
3	20	8	3
4	15	9	1
5	10		

It is to be noted that neither Innes nor O. Stone adhered to the literal text of their own prescribed conditions; but there is nothing wonderful in that, for consistency in adhesion to principles defined, is a rare virtue even with people who are not politicians.

The comprehensive character of three catalogues, which I have had constantly in mind, will be understood from the following enumeration of the stars included in each of them:—

Burnham (Northern stars to N.P.D. 121°)	13,665
Lewis (Σ stars exclusively)	3,134
Innes (all Southern stars)	2,195*

Innes's stars are numbered separately according to the hours of R.A. which yield stars varying in number from 54 (II^h) to 131 ($XVII^h$). The six hours, XIII to XVIII inclusive, embrace $\frac{1}{3}^{rd}$ of the total number.*

A caution (or suggestion) as to star magnitudes may here be made. A double star looked at as a single star will have a visual magnitude greater than the nominal magnitude of either of its components. For instance, a pair described in these pages as made up of two stars separately spoken of as "Mags. 7 and 7" will, taken together, shine as a single star, say of Mag. $6\frac{1}{2}$; and this fact must not be forgotten when any particular star is being searched for or gauged. Innes, in his catalogue of Southern Doubles, has attached to the numerous stars gathered together in what he modestly calls his *Reference Catalogue*, separate special figures suggesting the apparent magnitudes of all the pairs regarded as combined to form single stars. I am not aware of this ever having been done by any previous worker in this field.

Knott framed a comparative table of star magnitudes which will be found useful on occasions when

* The Stars in Innes's Supplementary Catalogue are not included in this enumeration.

the stated magnitudes of particular stars present discrepancies. The table runs as follows:—

Smyth.	Struve.	Sir J. Herschel.	Argelander.
6 ...	5·7 ...	6·4 ...	5·9
6½ ...	6·3 ...	7·0 ...	6·4
7 ...	6·5 ...	7·4 ...	6·8
7½ ...	6·9 ...	7·8 ...	7·5
8 ...	7·4 ...	8·2 ...	8·0
8½ ...	7·9 ...	8·8 ...	8·6
9 ...	8·3 ...	9·5 ...	9·0
9½ ...	8·9 ...	10·1 ...	9·4
10 ...	9·3 ...	10·4 ...	9·4
11 ...	10·0 ...	11·3 ...	10·0
12 ...	10·4 ...	11·7 ...	10·6
13 ...	10·7 ...	12·5 ...	11·2
14 ...	10·9 ...	13·3 ...	11·8
15 ...	10·9 ...	14·5 ...	12·4
16 ...	10·9 ...	15·9 ...	13·0

In regard to star magnitudes generally, it is much to be wished that Astronomers would come to a common understanding as to their estimation on some distinct instrumental photometric basis.

The system proposed by Dawes * of "limiting apertures" yields excellent results, but is troublesome of application. What is really wanted is a simple and inexpensive photometer capable of being applied to any telescope. The photometer used at Harvard College is most efficient, but it is only large observatories which can be equipped with elaborate instruments of that character.

In the observation of double stars there are several points to be borne in mind which frequently affect materially the success or failure of an observer's labours; and these are points which occasionally render it difficult to draw sound conclusions from what may seem to be the discordant results arrived at by different observers.

The question often presents itself, and is often asked, "What is the separating power of a given telescope?" And, as we have already seen, tests have been suggested based upon the angular distances of the components of stars. On this point it may be useful to add some remarks by Lewis:—"Theoretically, this, the separating power of telescopes, is not difficult to answer; but in most cases it is not the separating power that is really meant. What the enquirer usually seeks for is, rather, what we may call the observing or detecting power—the power to discriminate between a single and a double star. The separating power is given with sufficient accuracy by the formula:—

$$\text{Separating Power} = \frac{4\cdot56''}{a},$$

where a is the aperture of the object-glass in inches."

Applying this formula to the 36-inch refractor of the Lick Observatory and to the 28-inch Grubb of the Greenwich Observatory we obtain the figures 0·13″ and 0·17″ respectively, as the separating power of these telescopes, and it is said that under good atmospheric circumstances, stars at these minute distances can be seen as separate objects.

It may be useful therefore to provide a table of the separating power of refractors of moderate dimensions, as follows:—

Inches of Aperture.	Separating Power. ″	Inches of Aperture.	Separating Power. ″
1	4·5	4½	1·0
1½	3·0	5	0·91
2	2·3	5½	0·82
2½	1·8	6	0·76
3	1·5	7	0·65
3½	1·3	8	0·57
3½	1·3	9	0·50
4	1·1	10	0·45

It must be carefully borne in mind that when an observer is testing both his telescope and his own eyes at one and the same time his successes or his failures (whichever he may consider them) will depend on, and vary with, the four following factors:

(1.) The size of the object-glass.
(2.) The optical quality of the object-glass.
(3.) The condition of the atmosphere.
(4.) Himself personally.

The concurrent effects of these four factors, whether all together, or some only of them operating, will affect, often materially, his successes or his failures.

It is self-evident that comparing points (1.) and (2.) in the case of one telescope and another, very different results may be achieved; for even if two telescopes have object-glasses of the same size their optical quality may be very different. Again, a smaller telescope on a good night may yield results very different from, and much better than, those given by a better and even bigger telescope on a bad night. As regards personality, not only do the defining powers of the eyes of some people differ very much from those of others, but the eyes of the same person on different nights yield different results, dependent on the state of health, and bodily fatigue, or the contrary. Even the position of the observer's head and neck is a thing to be considered so as to avoid strain of the eyes which may be affected by strain of the neck. It may be regarded as a definite rule of considerable importance that all measures of the same star should so far as possible be taken under the like circumstances both of atmosphere and bodily position; but this may not always be easy of attainment.

The importance of the matters just mooted may, perhaps, be most definitely brought home to an observer's mind by the following striking remark penned by Burnham:—"An object-glass of six inches, one night will show the companion of Sirius perfectly; on the next night, just as good in every respect, so far as one can tell with the unaided eye, the largest telescope in the world will show no more trace of the small star than if it had been blotted out of existence."

* *Month. Not. R.A.S.*, Vol. X, p. 187, June 1851; Vol. XII, p. 80, Feb. 1852; Vol. XIII, p. 277, 1853.

XUM

To face page 290.

π Andromedae.

Mags. $4\frac{1}{2}$ and 9: Distance 36″.

ψ Carsiopeiae, Quadruple.

Mags. $4\frac{1}{2}$, 13, $8\frac{1}{2}$, 10: Distances $2\frac{1}{2}$″, 27″, $2\frac{1}{2}$″.

a Ursae Minoris.

Mags. $2\frac{1}{2}$, $9\frac{1}{2}$: Distance 18″.

Σ 133 Andromedae, Quadruple.

Mags. 7, $10\frac{1}{2}$, 11, 11: Distances 3″, 25″, 5″.

θ Eridani.

Mags. $3\frac{1}{4}$, $4\frac{1}{2}$: Distance 8″.

ξ Persei, Triple.

Mags. $3\frac{1}{2}$, 10, 11: Distances 12″, 32″.

XUM

STAR COLOURS.

As regards the colours often assigned to double stars, especially to small companions of a principal bright star, I am generally very sceptical. The refinements of language often indulged in by observers seem to me to be frequently carried to an absurd extreme. Admiral Smyth was a great offender in this matter, with his multiplicity of adjectives.* An enumeration of his variety of classifications under the main heads of "white" and "blue" respectively, will, I think, justify this criticism.

The following are among the shades noted in the *Bedford Catalogue*, as it left his hands in 1844:—

WHITE.	BLUE.
Bright White	Cerulean Blue
Brilliant White	Deep Blue
Bluish White	Dusky Blue
Creamy White	Fine Blue
Dull White	Indigo Blue
Flushed White	Light Blue
Intense White	Lucid Blue
Lucid White	Pale Blue
Pale White	Sapphire Blue
Pearl White	Sky Blue
Pearly White	Smalt Blue
Silver White	Very Blue
Silvery White	Bluish.
Very White	
Yellowish White	
Whitish.	

Yellow and red stars are handled in similar fashion, but the climax is reached when stars are spoken of as "dusky" and "flushed." With all my admiration for the good old Admiral and his racy and amusing *obiter dicta*, I cannot but feel that his knowledge of the English dictionary got the better of his discreet judgment.

As regards colour generally in connection with double stars, this much may be said to be noticeable. Red stars, very numerous in the heavens generally as isolated stars, are rarely met with as components of double stars; whilst other colours (blue, green, yellow, and so on) are common in double stars, but are rare in the case of isolated stars. I have no theory to suggest as to these singular facts, nor do I know of anyone having suggested an explanation.

Where the two components of a double star are nearly or quite equal in magnitude, it will sometimes happen that one observer will take one star and another observer the other star as his centre for measuring the position angle. The two angles will therefore in such a case seem to be irreconcilable because they differ by 180°, when in reality they are quite comparable.

Innes has made some remarks † on the colours of double stars, which deserve a passing notice. He has applied to his stars an arbitrary scale from 0 to 10, the former signifying a white star, and the latter an intensely red star, the intermediate numbers representing various stages from white to red as follows:—

0 White	6 Orange Red
1 Yellowish	7 Reddish
2 Yellow	8 Red
3 Deep Yellow	9 Very Red
4 Orange Yellow	10 Deepest Red
5 Orange	

He also employs the words "bluish," "blue," "purplish," "yellowish" and "yellow" where their application seems expedient. He remarks, most sensibly and truly, that:—"It seems useless to go in for further sub-divisions, or for fancy names of colour which can only convey distinct meanings to their actual author."

Innes has drawn up some colour statistics respecting the double stars which he has himself observed, remarking however, very truly, that if the companion of a principal star "is very faint it is impossible to estimate its colour."

He is not very explicit as regards the number of the stars which he has brought under review for forming his statistical table, but here it is for what it is worth:—

	Proportion Per Cent.		Average Difference of Magnitude.
Both stars white to yellowish but of the same tint ...	29	...	0·4
Both stars of the same tint, but decidedly yellow ...	19	...	0·4

After presenting the foregoing figures he has tacked on the following:—

	Proportion Per Cent.		Average Difference of Magnitude.
Both stars of the same tint ...	48	...	0·4
Chief star yellow or yellowish, but the companion decidedly a deeper yellow	4	...	2·5
Chief star yellowish, companion bluish...	16	...	2·4
Chief star full yellow, companion bluish	23	...	2·2
Chief star yellow or yellowish, companion blue	8	...	2·9
Chief star bluish, companion yellow or yellowish" ...	1	...	1·0
	100		

It seems to me a very noteworthy fact that 47 per cent. of the companions of Double Stars should be blue or bluish.

(To be continued.)

* But Struve was a "good second" in this competition: as witness *Olivaceasubrubicunda*, a word which for minute detail and linear length is not often surpassed even in Teutonic literature.

† *Annals of the Royal Observatory of the Cape of Good Hope*, Vol. II, pt. 4, p. x, 1905.

XUM

THE EXTERMINATION OF BIRDS.

It is considered right that we should preserve for posterity the great works of our forefathers, and as heavy if not heavier an obligation rests upon us to ensure that our children's children shall not be bereft of the heritage of beauty which nature has evolved during countless years, beside which the age of man is a negligible quantity. Granting this, why, may we ask, to take a special case, should the lovely white heron be a misty remembrance fifty years hence, and the whole world be without it, because to-day it is the fashion for thoughtless, if not heartless, women to wear aigrettes in their hats? There is every aesthetic reason against the idea. Of all creatures, probably birds appeal most to the human mind; their form, their movements, their flight, their song, and their domestic life all tend to attract and maintain our interest.

There is, however, a practical and a scientific side to the question, for a very great number of birds are the friends of agriculture and contributors to national prosperity. The true naturalist, for scientific reasons, grieves to see any bird exterminated; his sympathy would probably extend even to those species which on occasion make themselves a nuisance to mankind, but no objection can be brought against the greater number of the birds which are sacrificed for their plumage.

At a recent meeting of The Selborne Society, Mr. James Buckland gave an address on "The Traffic in Feathers and the need for Legislation," and, by the courtesy of the Secretary of the Textile Trade Section of the London Chamber of Commerce, we have received a copy of the answers which, on behalf of the feather dealers, have been given to the statements then made.

We have further submitted these to Mr. Buckland, and we pick out some of the more important points in the hope that our readers will be able to give us first-hand information with regard to them. To begin with, Mr. Buckland claimed that the white heron is practically exterminated both in North America and in China.

To this the trade circular replies as follows:—"If the birds have disappeared from some of the more open regions in China, it is perfectly safe to say that countless thousands have retired to less accessible districts in order to avoid molestation." Mr. Buckland points out that the "molestation" did not come from the inhabitants of China. "The birds nested in trees in closest proximity to human habitations, for no man nor boy in China harmed the herons. They were not good for food, but they were good to see, so painters painted them, poets used them for their similes, and all China hallowed them." It was from China, he says, that the first supplies of aigrettes came, and it was only when this source had been dried up that the attention of the destroyers was turned to Venezuela and elsewhere. We should be glad to hear, from some one personally acquainted with China and its "less accessible districts," in what numbers the white heron is now to be found there.

The trade circular tells us that in the Everglades of Florida the white heron is still very plentiful. Here again we should like some first hand-information.

With regard to Mr. Buckland's evidence that the number of egrets killed in Venezuela has greatly decreased since 1898, the trade states that he has made a mis-use of figures. These were, Mr. Buckland says, taken from the Consular reports, and there should be no difficulty in satisfying oneself as to who is speaking the truth. We notice that the trade circular claims that the value of egret feathers exported in 1898 was less than twenty thousand pounds, while in 1908 the value was thirty-one thousand, eight hundred and six. As the price of aigrettes has risen greatly of recent years, it is obvious to anyone who thinks, that the amount of feathers exported is not indicated in any way by these figures. In fact it seems likely, if one were to take the trouble to compare the values of the feathers in the two years mentioned, that Mr. Buckland's statements would be proved. We should like to hear of anyone who has collected moulted feathers, and details of the preserves, called Garceros, would be most welcome. We should advise Mr. Buckland, in future, when he shows his slides of the starving nestlings, to emphasise the fact that they were taken in Australia, and not in Venezuela; but, no doubt, as they are so well known, he did not anticipate that his opponents would accuse him of having "used them to support the case against Venezuela."

To the statement that there is no demand for humming birds, Mr. Buckland replies that over twenty-six thousand have already been catalogued for sale in London during the present year. We should like independent evidence with regard to the shore birds from the Atlantic coast of the United States of America. The trade says that "It is physically impossible to denude of birds those thousands of miles." Mr. Buckland's answer is that had it not been for the establishment of reservations there would not be a gull or tern left.

We should not like to suggest that the wardens of the reservations who were killed, were murdered by accredited representatives of the plumage trade, but few will doubt but that the murderers, whoever they were, came after feathers. In reply to a further statement about poaching, Mr. Buckland refers to an article by him in the current (August) number of *The Selborne Magazine*.

We understand that more carefully considered answers are being prepared by the representatives of the plumage trade, and we are glad to learn from the newspapers that many of the milliners are in favour of the Bill being passed which is now before Parliament.

XUM

NOTES ON THE PERSEID METEORIC SHOWER.

By W. F. DENNING, F.R.A.S.

THERE are many hundreds of meteoric showers; some of them are of regular annual occurrence, others afford periodical displays. We do not know how many systems exist and intersect the earth's orbit, nor are we well acquainted with the precise character of a large proportion of the minor showers already observed.

Perhaps the great Perseid shower of July and August is the most important and best known of all the streams displayed in the firmament. It returns every year, is fairly conspicuous, and lasts a long time. Even at the middle of July its fine streak-leaving meteors begin to show themselves, often crossing the "Milky Way" in Cygnus and Cepheus, or shooting amongst the stars of Pegasus, Andromeda, Draco or Ursa.

The number of meteors increases until about the 12th of August, when the rate varies between twenty and one hundred per hour. In certain years there are more than others, and sometimes atmospheric conditions are specially adapted for such observations. Of course, phenomena of this kind are best viewed in the absence of moonlight, and when the air is very transparent and free from haze and fog.

It is the Perseids which render August skies so attractive to the meteoric student, but these meteors are no longer to be seen after the third week of the month.

The Perseids have a parent comet, but the evidence associating the meteors and comet cannot be said to afford absolute proof. There is, however, a significant agreement, if not identity, in the orbits, but the periodic times are unknown. In the cases of the Leonid and Andromedid comets, their physical association with the meteoric systems can hardly be disputed when all the facts are impartially considered, but in regard to the Lyrid and Perseid showers their supposed derivative comets may just possibly be due to accidental coincidences.

When the Perseid maximum recurs this year the moon will be in her first quarter and will set soon after 10 p.m. Then, with clear weather the meteors ought to be viewed under the best conditions. It is hoped that a great number of observations will be effected this year, and that many of the brighter meteors will be recorded in duplicate by various observers who may be watching the sky at the same times. Duplicate or multiple records of the same objects enable their real paths in the air to be computed.

A watch of two or three hours on any clear moonless night during the first half of August will generally yield a sufficient number of Perseids to indicate the radiant point pretty accurately. And it is important that the precise focus of radiation be fixed on every available night, so that the displacement remarked in previous years may be amply and conclusively affirmed.

It is fortunate that the Perseid meteors may be very accurately recorded. Their lines of flight can be fixed from the phosphorescent streaks which are projected along a portion of the tracks. In the majority of instances the streaks endure for a very few seconds, but celerity on the observer's part will enable the directions to be very correctly noted if he projects a straight wand upon the streaks and remarks exact positions relatively to the stars near the lines of trajectory in a backward direction.

In the case of a brilliant meteor there will be a flash and a durable streak visible to the eye from ten seconds to ten minutes in different cases, according to the magnitude of the object. But the direction of flight must be obtained from the streak instantly on its appearance, for it immediately becomes displaced amongst the stars by the action of wind currents in the upper part of the atmosphere.

The streaks of the Perseids are usually between seventy and fifty miles high, and the denser and more durable part is frequently from sixty to fifty miles in altitude. The meteors seldom penetrate nearer to the earth's surface than forty miles. In fact the swift class of meteors like the Perseids, Orionids and Leonids are comparatively high in the air, and one of them has never been known to descend upon the earth. It is the slow moving fireballs and shooting stars, which overtake the earth in her orbit, that sometimes withstand disruption until they are only between twenty and thirty miles in height.

We have already learnt much about the August meteors, but there is much more knowledge to gain concerning these erstwhile "fiery tears of St. Lawrence." Apart from the scientific importance of witnessing the display and noting its leading characteristics, it forms an event of considerable attraction from a spectator's point of view. Any observer who appreciates the more striking phenomena of nature can view the nocturnal sky on August 11th, 12th or 13th, and find it exceptionally entertaining from the abundance of its meteors. Small objects scarcely visible to the acute eye will be noticed, interspersed with occasional fireballs illuminating the sky with lightning-like flashes. Whatever the position of the meteors, be they in the N., S., E. or W., their paths will nearly all be found conformable to one and the same centre in Perseus. There may be a few erratic flights from the minor showers of the period, but there will be no danger of mistaking them for Perseids, owing to their difference in direction and apparent velocity.

XUM

THE LIFE HISTORY OF A PEAT-MOSS.

By PROFESSOR F. CAVERS, D.Sc., F.L.S.

Hartley University College, Southampton.

(*Continued from Page 268.*)

THE growth of a Peat-Moss shows a more or less marked annual periodicity, the activities of the plant being slowed down in winter, though never actually brought to a standstill, except when the temperature falls to freezing-point and ice is formed. The study of plants at intervals throughout the year shows that, in general, the laying-down of new branches at the apex of the stem proceeds during the whole growing-period (spring to autumn), but the elongation of the stem becomes arrested in late summer or early in autumn. While the stem is lengthening, the outermost, *i.e.*, oldest, of the branches forming the cushion-like top of the plant are continually being carried downwards and spaced out in tufts on the stem. As we have seen, one of the late-formed resting-branches may, after the winter rest, grow up as a continuation shoot, or branch of "unlimited" growth, keeping pace with the growth of the parent axis, which thus appears to become forked. Among the later branches found in autumn, some differ from the ordinary vegetative branches, and bear the sexual organs. The male and female branches may either occur on the same plant (*monoecious* condition) or on distinct plants (*dioecious* condition); the majority of the British species of *Sphagnum* are dioecious, but some show either condition quite indifferently, and are sometimes monoecious, at other times dioecious. When the plant is monoecious, the male organs (*antheridia*) are developed before the female organs (*archegonia*), the male branches being carried downwards on the stem as the latter elongates, while the female branches arise later and are found, in spring and summer, on the upper part of the plant, in the position previously occupied by the male branches, but later still the female branches are also carried downward as the stem lengthens.

FIGURE 1.
A female branch of *Sphagnum acutifolium.*

The sexual organs are usually mature in late autumn and winter, and may be found fully developed in mid-winter, even when the plants are covered with snow. In this condition they remain until the first warm days of spring, when they open and fertilisation occurs; the embryonic capsules may be found as early as February, and their development proceeds during spring and summer, the capsules ripening and shedding the spores from July to September.

FIGURE 2.
A male branch of *Sphagnum acutifolium.*

The male branches (Figures 2—4) are at first indistinguishable from the ordinary divergent branches of a branch-tuft, but by the time the antheridia are produced, the male branch acquires a characteristic appearance. One or more of the branches of a tuft, after growing in the usual way at first, expand and become catkin-like, and above this swollen region (in which the antheridia are formed) taper again to a pointed tip which may continue to grow like an ordinary branch, giving the catkin a spindle form. The leaves which protect the antheridia resemble the ordinary branch-leaves in general structure, but are usually shorter, more closely overlapping, arranged in regular straight or spiral rows, and often richly coloured —red, purple, brown, and so on—even in species where the ordinary branches are devoid of colouration other than pale green, so that the male branches are as a rule easily recognised by their external appearance. Sometimes the male branch, though at first a compact catkin, becomes loosened out owing to the elongation of its axis, so that the antheridia are seen on the surface, and the branch droops like one of the ordinary pendent branches.

FIGURE 3.
A male branch of *Sphagnum cymbifolium.*

The antheridia are spherical, and attached to the axis of the branch by a slender and relatively long stalk (Figure 4,) which is inserted beside the base of a leaf. The position of the antheridia with reference to the leaves is therefore the same as that of a branch on the stem, and, as a matter of fact, a bud is occasionally seen occupying the place of an antheridium. The developing antheridia are well protected by the overlapping leaves, and it was formerly supposed that the antheridia were accompanied by

branching hair-like outgrowths which kept them moist. In quite recent books on mosses, along with various other errors which have been copied by writer after writer, we find these "hairs" mentioned, comparison being made between them and the hair-like outgrowths (paraphyses) which accompany the sexual organs in other mosses. Schimper (1858) described and figured these supposed paraphyses in *Sphagnum*, but as a matter of fact they are only of occasional occurrence, and, moreover, they do not belong to the *Sphagnum* plant at all, but to a parasitic fungus, to which reference will be made later.

Since antheridia of all ages may be found on a male branch examined in autumn or winter, the development of these organs is readily followed out. As is usual in mosses, each antheridium arises from a single surface cell of the stem, beside a young leaf in this case. This cell grows out and divides repeatedly by transverse walls, growing in length meanwhile, so as to consist of a row of cells. Then the cells, except the end one, divide by longitudinal walls, so that the young antheridium now consists of a stalk, composed of several (usually four) rows of cells, and a terminal cell. The latter then divides by inclined walls cutting each other, in such a way as to give rise to three rows of cells, which by further growth and divisions produce the nearly spherical body of the antheridium, and this, when ripe, consists of an outer layer of large cells and an internal mass of much smaller sperm-cells. Each sperm-cell finally produces a corkscrew-shaped sperm, with two swimming-threads attached to its narrow end, which is directed forwards in swimming, and a small pear-shaped starchy mass fixed to the thick hinder end to serve, doubtless, as a store of food for the voyage of the sperm in search of an archegonium that it may fertilise. The ripe sperms are set free, when the first warm days of early spring arrive, by the bursting of the antheridium at the top, where the outer cells swell up and separate from each other (Figure 5).

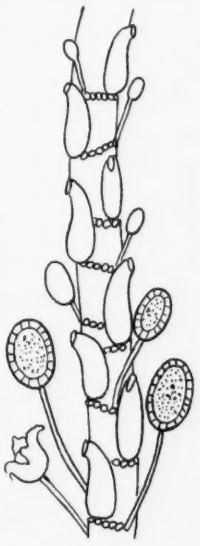


FIGURE 4.

Part of a male branch of *Sphagnum*, from which the leaves have been removed, showing the antheridia and the retort-cells.

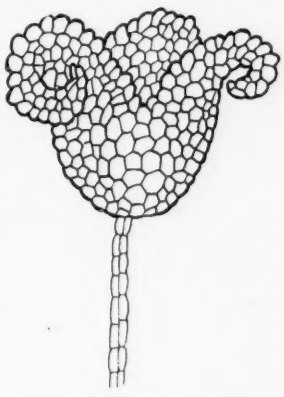


FIGURE 5.

An antheridium after it has burst and set free the sperms.

The female branches (Figure 1) are very short, and are easily distinguished from all the other kinds produced by the plant. They develop later than the male branches, and therefore remain, at any rate until fertilisation has taken place, on the rounded top of the plant. Their late appearance is connected with the fact that very few archegonia are formed on each as compared with the numerous antheridia of the male branch; the best position for the long male branch, in order that it may be kept moist—since the sperms of course require water to swim in—is lower down on the plant, but the chances of fertilisation are obviously increased by the position of the female branch high up on the surface of the cushion-like plant, where water containing the swarming sperms can readily reach the archegonia.

The female branch grows for some time in the same way as an ordinary sterile branch, but the leaves visible from the outside of the branch become rapidly longer in passing from below upwards, so that the branch takes the form of a loose tapering pointed bud, deep green in colour, and stands out sharply from the vegetative branches associated with it. Apart from their shape, the vivid green colour of the female "flowers" enables one to pick them out from the other branches on the cushion-like top of the plant, where they are often present in large numbers. The leaves externally visible at the top of the female branch, also, are usually much larger than any other leaves on the plant, and they differ from the branch-leaves, on one hand, in having few fibres in the hyaline water-cells, and from the stem-leaves, on the other, in having abundant chlorophyll. The peculiarities in the structure of these leaves of the female branch are readily understood when we remember that their functions are to protect, and to a large extent to supply food to, the developing spore-fruit in the early stages of its growth; owing to the scarcity of fibres in the cells, these leaves closely invest the young fruit instead of being stiff or curved outwards, and their abundant chlorophyll enables them to manufacture nutritive organic substances.

Within the large enveloping leaves we find, at the growing apex of the female branch, a small group of female organs, or archegonia, surrounded by a number of small leaves which for a long time remain in an embryonic or undifferentiated condition (Figures 6-8). The first archegonium is formed from the apical cell of the branch, and then from two to four others are developed around it; occasionally there may be only two of these organs, or no more may develop after the first one. The archegonium of *Sphagnum* resembles that of other mosses in structure and development; it has a massive stalk, a dilated portion (venter) containing the egg-cell, and a somewhat twisted neck containing a row of canal-cells. As in the case of the antheridia, Schimper described and figured fine branching threads, mixed with the archegonia, and mistook

these for outgrowths of the plant, serving to keep the archegonia moist—as we shall see presently these "hairs" are simply the threads of a parasitic fungus.

The opening of the ripe archegonium and the entrance into it of the sperms do not appear to have been described since Roze's paper on *Fertilisation in various Cryptogams*, published in 1864.

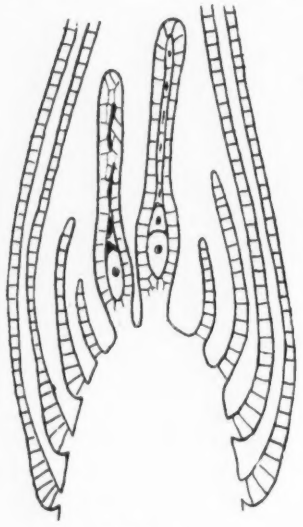


FIGURE 6.

A longitudinal section of a female branch of *Sphagnum*, showing two archegonia at the apex of the stem, and a number of leaves below them.

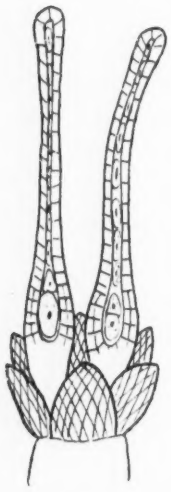


FIGURE 7.

A female branch from which nearly all the leaves have been dissected, showing the youngest leaves and two archegonia.

He placed some mature but still closed archegonia in water on a slide, and found that dehiscence took place after about an hour's immersion; he then placed in water some antheridia, which, on rupturing, charged the fluid with abundant sperms (antherozoïds), and some of this he added to the other preparation. He found that the sperms apparently showed no tendency to direct themselves towards the entrance of the canal, but reached it fortuitously, and then appeared to enter it with difficulty; the ciliated end went first and was sometimes arrested by the "plasma" in the canal, but after freeing itself with a struggle moved on more briskly until it reached the egg suspended in the fluid in the archegonial cavity and fixed itself to this. Roze's account appears to be correct in all essentials, but he did not observe the actual fusion of sperm and egg, nor did Waldner, who in 1887 gave a brief description, with excellent figures, of the early development of the embryo from the fertilised egg.

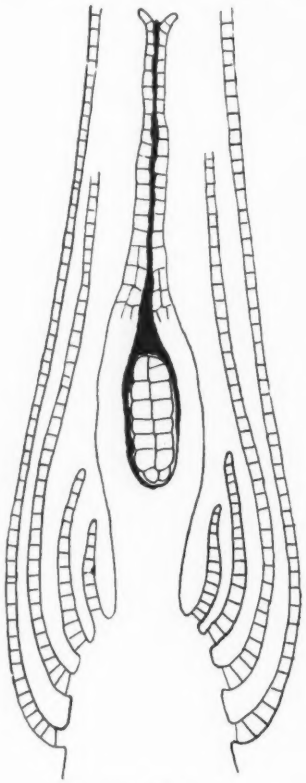


FIGURE 8.

A longitudinal section of a female branch, showing a fertilised archegonium containing an embryo.

The writer has made a careful study, largely by means of serial microtome-sections, of the development of *Sphagnum*, some of the results being incorporated in this paper. The attraction of the sperms to the archegonium was found to present some curious and interesting features. The canal-cells of the ripe archegonium become disorganised, and the cavity of the venter, surrounding the comparatively small egg, is filled with the resulting slimy fluid, which stains deeply in microtome-sections, and which gives the reactions of proteid substance. Some of this slime oozes from the neck of the archegonium, when it opens, owing to the swelling of the canal contents on absorbing water. In a series of experiments, fine tubes were filled with the substance whose action on the sperms was to be tried—soluble proteids, sugars, organic acids, various salts and so on were used,—and the open end of the capillary tube was introduced into water containing active sperms. It was found that the sperms gave definite responses to several of the substances used, but that the soluble proteids and peptones induced the most rapid and definite responses, and there can be little doubt that the proteid matter extruded by the archegonium definitely "attracts" the sperms to the open neck. Lidforss (*Jahrb. für wiss. Bot.*, 1904) showed that the sperms of the liverwort *Marchantia* are most strongly

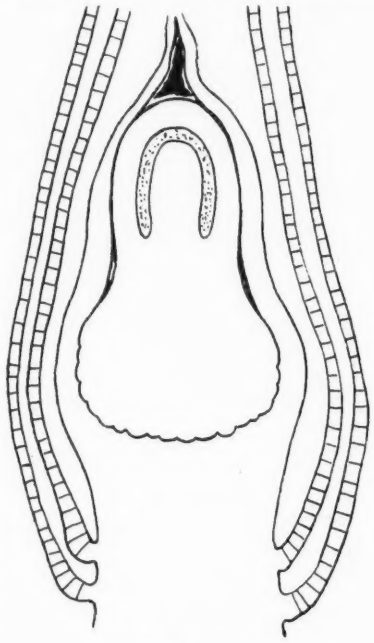


FIGURE 9.

A similar longitudinal section, showing an older embryo.

attracted by proteids, in this respect resembling those of *Sphagnum*. The sperms of our plant, like those of mosses and ferns in general, rotate on their axis while swimming, with the narrow ciliated end directed forwards. On entering the extruded slime outside the archegonium neck, the sperm's movements slow down, but only in few cases was a sperm seen to turn its axis directly towards the neck (or towards the open end of the fine tube used in the experiments) and to make, as it were, a bee-line for the latter. In most cases the sperms, which had until then been swimming about in various directions at haphazard, actually turned away on coming within the "sphere of influence" of the attracting substance! Some of them even turned back and swam off, but, more often, after showing this apparent repulsion movement, the sperm hovered about in a complicated and undecided zig-zag or spiral course, and finally slipped into the opening. This curious behaviour of the sperms of *Sphagnum*, agrees closely with the reactions to chemical stimuli which are shown by various Protozoa and Bacteria, as described by Jennings in his book "*The Behaviour of the Lower Organisms*" (New York, 1906), and also with some of the movements observed quite recently by Hoyt (*Botanical Gazette*, May, 1910), in the sperms of ferns.

FIGURE 10. An embryo in the three-celled stage.

FIGURE 11. A slightly older embryo.

When the egg is fertilised, it becomes clad with a cell wall, and divides first into an upper and a lower cell; the latter apparently undergoes only a few irregular divisions, while the former divides by repeated horizontal walls, so as to form a row of about six cells (Figures 10-12). Each of the cells in this row then divides up in such a way as to separate a series of inner cells from a layer of outer cells. The embryo soon becomes pear-shaped, the narrow upper portion eventually producing the capsule, while the lower portion at first grows much more rapidly, and forms a large bulbous organ by means of which food is absorbed from the female branch. It is interesting to note the enormous early growth of the basal portion or "foot" of the embryo, which encroaches on the tissue of the female branch and enables the spore-capsule to live as a parasite on the plant; the surrounding tissue of the stem expands to accommodate the enlarging foot of the young capsule, the superficial cells of the foot growing out into short finger-like processes and destroying the cells with which they come into contact, so that the lower part of the embryo burrows in the tissue of the branch, in much the same way as the sucking organ of a parasite, like the dodder in the tissue of its "host." The growth in size of the young capsule lags behind that of the foot, but gradually the capsule becomes egg-shaped, or nearly spherical, being separated from the foot by a deep constriction (Figure 13). At an extremely early stage in the development, however, a layer of tissue is differentiated in the upper portion of the capsule, having the form of an inverted bell-glass (Figure 9). This layer eventually produces the spores, and its cells are recognised readily at an early period by their staining much more deeply than the other tissues of the capsule; later this spore-producing layer *(archesporium)* becomes four-layered, and the cells

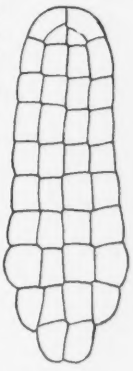


FIGURE 12. An older embryo still.

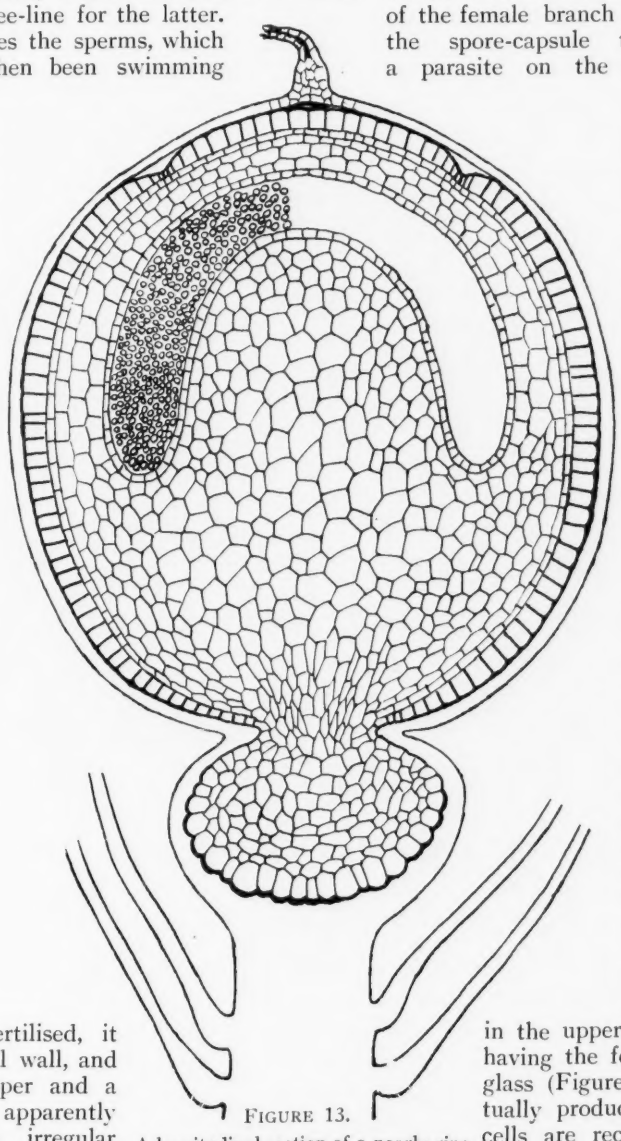


FIGURE 13. A longitudinal section of a nearly ripe *Sphagnum* sporogonium.

At the top is the withered neck of the archegonium, the lower part (calyptra) of which covers the nearly spherical capsule. The capsule-wall shows the groove which separates off the lid. The dome-like spore-sac (spores only shown on left side), and the central tissue (columella) are seen. The capsule is connected by a constriction with the absorbing foot.

immediately adjoining it, on both the convex outer side and the concave inner side, divide so as to form a small-celled layer (sporesac) enveloping it. (Figures 13 and 16).

While the embryo is growing and becoming differentiated into the spore-producing capsule and the food-absorbing foot, the adjoining parts of the female branch are undergoing changes. The stalk of the archegonium itself broadens out as the foot bores down into it and into the underlying tissue of the stem, and at the same time the leaves surrounding the archegonium, which have hitherto remained in a rudimentary condition, are stimulated by the act of fertilisation, and grow up so as to surround the growing capsule (Figure 9), their cells becoming differentiated into hyaline and green cells like those of the ordinary leaves. The lower part of the venter of the fertilised archegonium also expands so as to keep pace with the enlargement of the capsule, and the withered brownish neck and upper portion of the venter are carried up on the surface of the sheath *(calyptra)* which invests the capsule.

Returning to the developing capsule, we find that a certain amount of chorophyll is present, especially in the tissues lying outside of the spore-sac and in the small cells of which the spore-sac itself is composed; hence the growing capsule is doubtless enabled to manufacture a small amount of organic food to supplement that which it draws from the female branch. As the capsule matures, the cells of its superficial layer acquire thickened and brown-coloured walls, so that the whole capsule is covered by a sharply-marked epidermis. Long before the capsule is ripe, a ring-like groove is marked out in the upper region; the epidermal cells along a circular transverse line in this region grow less actively than their neighbours, and thus remain small, indicating the limit of the circular lid by which the ripe capsule will open. In many of the higher mosses, the epidermis of the capsule bears air-pores or stomates, resembling those on the leaves of higher plants in being bounded by a pair of curved guard-cells. In *Sphagnum*, we find on the capsule large numbers of rudimentary stomates, whose development has been arrested. These begin to develop in the usual way, isolated epidermal cells here and there remaining thin-walled and dividing into two cells lying side by side; but the partition-wall between these "guard-cells" does not split to form a pore, as can easily be seen on comparing tangential and vertical sections of the epidermis (Figures 14 and 15), or this middle wall may split for some distance inwards, but never so completely as to separate the two cells.

When the capsule is ripe, it becomes raised up on what appears at first sight to be a stalk of its own. But closer examination shows that this "stalk" is simply formed by elongation of the upper part of the axis of the female branch; the uppermost leaves of the branch become somewhat spaced out owing to this elongation of the stem, but the growth in length is greatest between these leaves and the fruit itself, so that the "stalk" appears quite smooth on the surface and consists of elongated cells. The top of the "stalk" is occupied by the bulbous foot of the capsule. The capsule itself is at first covered by the thin sheath, but this becomes ruptured irregularly by the slight expansion of the capsule, leaving a cup-like portion behind; sometimes the rupture is more regulary transverse, so that the upper part of the sheath, capped by the withered archegonium, is seen for a time at the top of the capsule, but it soon disappears.

Reference has been made to branching threads which ocasionally occur associated with the sexual organs, and which were regarded by the earlier workers on *Sphagnum* as being part of the plant itself, and as serving to keep the antheridia and archegonia moist. Doubt was thrown on this interpretation by later observers, including Leitgeb, who investigated the development of the antheridia, and Waldner, who worked out the embryology of the spore-fruit; neither Leitgeb nor Waldner found these threads at all. Schimper and other early observers noticed that the capsule sometimes contains very small spores which to a greater or less extent replace the ordinary spores. To these small spores Schimper gave the name "microspores," and his account of the supposed formation of these spores by repeated division of the ordinary large spores has been copied into practically all books dealing with the mosses, as has also Warnstorf's suggestion that the "microspores" in dioecious species give rise to the male plants, and the ordinary larger spores to the female plants. If this were true, *Sphagnum* would differ from all the other Bryophytes (liverworts and mosses), and the great majority of the Pteridophytes—though resembling some of the latter (certain ferns, *Selaginella*, and so on)—in having small "male" and large "female" spores.

However, Waldner was unable to find any trace of Schimper's "microspores" in the capsules which he examined, and Goebel had already (1882) suggested that these small spores, as well as the threads found by Schimper associated with the sexual organs, might belong to a parasitic fungus. This was confirmed in 1892 by Nawaschin, who worked out the life-history of the fungus, tracing its entrance into the developing capsule and its ramification through the spore-forming tissue, where it produces its own spores, mingled with the spores of the *Sphagnum*, or even, in small and deformed capsules, replacing them entirely. He named the parasite, *Tilletia Sphagni*, and showed clearly that the threads which infect the male and female branches simply form part of the fungus, which only produces its spores when living at the expense of the well-nourished spore-sac of the moss capsule.

The scattering of the spores from the ripe capsule of *Sphagnum* is brought about by a curious and interesting mechanism. Long ago it was noticed that the capsules explode with a crackling noise, the

shape of the capsule changing from spherical to cylindrical, and the lid, together with the spores, being thrown off to a distance of several inches. This takes place on sunny days, and it is quite easily observed if plants are closely watched on a bright warm dry day in late summer or early autumn, or if some fruiting plants are brought indoors and placed in a dish covered with a sheet of glass—the shot-off lids will be after a time seen on the underside of the glass. The mechanism of this extraordinary process, which evidently occurs with explosive violence, was first explained by Nawaschin in 1897. As the ripe capsule dries up, the central delicate tissue (*columella*) within and below he spore-sac shrivels and is replaced by air, so that the capsule eventually contains, within the brown epidermis layer, practically nothing except the spore-sac (which has by this time assumed the form of an inverted saucer-like bag within which the spores lie loosely) and below this a large air-cavity (Figure 18). Air enters through the epidermis, probably by way of the thinner-walled "guard-cells" of the rudimentary stomates, as long as the capsule is fairly moist, and accumulates in the place previously occupied by the central tissue. As drying proceeds the longitudinal diameter of the capsule remains unchanged, but the transverse diameter is greatly shortened owing to transverse contraction of the epidermis, and the imprisoned air below the spore-mass is therefore compressed (Figure 19). During this contraction of the capsule to a cylindrical form, the lid (which is firmer in texture than the rest of the capsule-wall) shrinks less than the capsule itself, and in this way a difference in tension is set up, owing to which the lid becomes loosened from the capsule, along the groove (*annulus*) which limits it. Finally, the lid gives way and is forcibly shot off, along with the spores, by the explosion of the compressed air, in exactly the same way as a bullet is from an air-gun! The spores are scattered, as each capsule explodes, in a yellowish or orange-coloured cloud, and are readily carried away by the wind; and if one is watching the process at close quarters, the ejected lids are often thrown into one's face. If one is not successful in observing these explosions in the field, it is easy to prove in another way that the capsules really do open in the manner described. On taking home some fruiting plants and pressing them between large sheets of paper under a board on which is placed a weight of not more than about a pound, the capsules will open in the normal manner on drying, and the spores will be seen forming streaks of powder (yellow or reddish-yellow according to the species) extending across the paper from the ruptured capsules, the lid itself lying at the far end of the streak. The explosion can also be observed on placing isolated female branches, or cut-off ripe capsules, on a glass slide and leaving them to dry; or by treating ripe capsules with drying agents such as glycerine or alcohol. I have often noticed the ejected lids sticking to the inside of glass jars containing fruiting *Sphagnum* plants which had been preserved in alcohol for laboratory-class use.

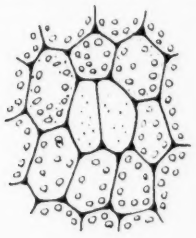


FIGURE 14.

Part of the epidermis of a young capsule, in surface view, showing one of the rudimentary stomates.

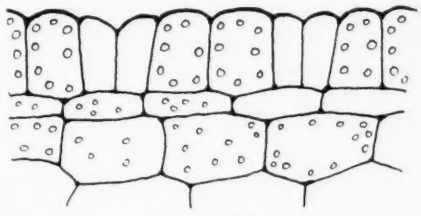


FIGURE 15.

Part of a transverse section of a young capsule, showing two of the stomates.

Nawaschin measured the volume of the air contained in ripe capsules by measuring the radius of the roughly spherical air-cavity and calculating its volume on the formula:—$V = \frac{4\pi r^3}{3}$ and by pricking capsules open under mercury and measuring the volume of air (at normal atmospheric pressure) which escaped and was collected in a "eudiometer." He found that the volume of the air-cavity in the ripe, but still moist and spherical, capsule was nearly three cubic millimetres; the volume (measured at normal atmospheric pressure) of the air-bubble obtained by opening the capsule in this condition was on the average over four cubic millimetres, but was sometimes over five cubic millimetres; while the volume of the compressed air in the air-cavity of the dried-up cylindrical capsule was less than 0·8 of a cubic millimetre. That is to say the air in the dry capsule, just before the explosion takes place, is under a pressure of from four to six atmospheres, which fully accounts for the violence of the explosion. In respect of this curious and beautiful explosive "pop-gun" or compressed air mechanism for the dispersal of the spores, the peat-mosses apparently stand alone, not only among the mosses, but in the entire plant world.

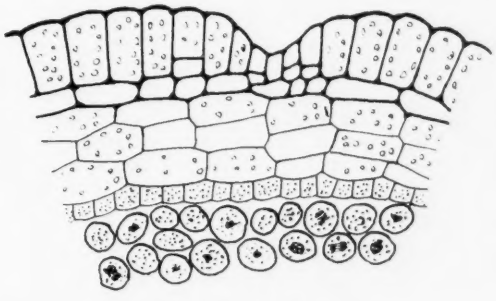


FIGURE 16.

Part of a longitudinal section of a capsule, in the region of the groove (annulus); on the outside is the capsule wall, and towards the inner side the spore sac, with some of the dividing spore-mother-cells.

XUM

As a rule the female branch remains at the top of the plant until the capsule has exploded and scattered the spores, but sometimes the stem elongates in this region, and thus the capsules are carried down and left behind at various heights on the stem; this occurs especially when the plants are suddenly submerged by a wet season. It is obviously an advantage to keep the fruits at the free surface of the cushion-like plants until after spore dispersal, so that the spores may have a chance of being wafted away by air-currents. If the fruiting plant is kept wet the capsules do not open in the ordinary way, but in such circumstances the capsule often becomes detached from its foot, and as the columella decays, a

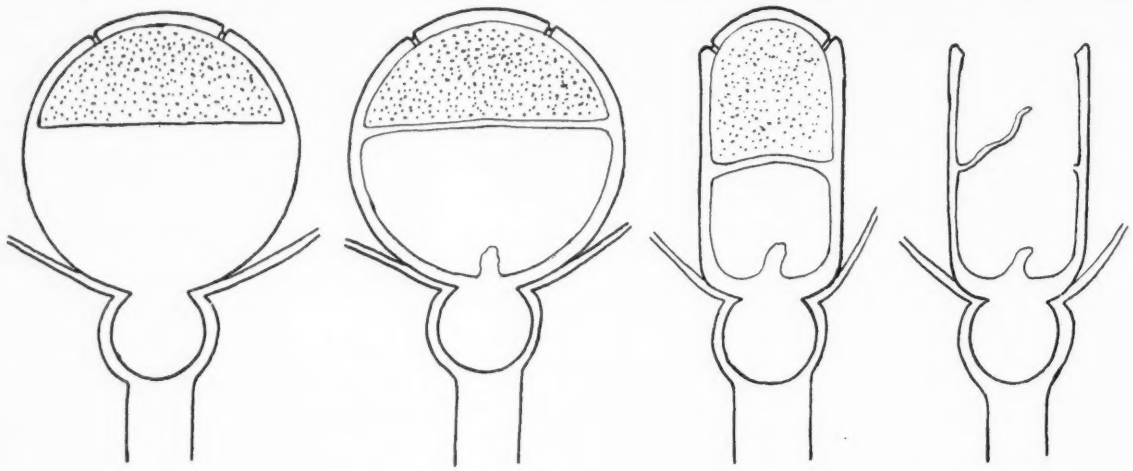


FIGURE 17.
A ripe but still moist capsule; below the spore-sac is the delicate tissue of the columella which is still intact and unshrunken.

FIGURE 18.
Practically the whole of the columella has shrunken and collapsed, leaving an air-space below the spore-sac.

FIGURE 19.
The capsule has now contracted strongly, so that the air is under considerable pressure.

FIGURE 20.
Longitudinal section of an empty capsule; the lid and the spores have been forced out.

A series of diagrammatic longitudinal sections to illustrate the explosive opening of the ripe *Sphagnum* capsule.

hole is left at the base of the capsule by which the spores may escape.

The germination of the spores of *Sphagnum* differs from that observed in most mosses. The spore, on being kept moist and warm, swells up and its contents break through the cell-wall or spore-coat, growing out and producing a colourless thread (*rhizoid* or rooting-hair) which grows down into the soil, and a green thread which grows horizontally, and at first divides, by transverse walls, so as to form a row of cells. The end-cell of this green thread soon divides up in such a way as to form a rounded disc, which is often heart-shaped for a time, like the prothallus of a fern. Later on this disc, or protonema, becomes an irregularly lobed expansion, consisting of a single layer of cells and reaching a diameter of several millimetres; it is attached to the soil by numerous colourless rooting hairs. The protonema may reproduce itself by sending out from its margin threads which give rise to discs, and these may later become separated from the parent protonema. As a rule, only one leafy plant arises from each protonema, in the form of a projection produced by active growth and division of a marginal cell at the base of the protonema; in this cell walls arise which cut out a pyramidal apical cell, and this proceeds to develop leaves. The fourth or fifth leaf of the young plant already shows the differentiation into green and hyaline cells characteristic of the mature leaves; the first leaves in which this differentiation appears only show it in the lower part, the cells at the top of the leaf remaining uniform and green. Schimper stated that when the spores are sown in water the protonema is thread-like, but Goebel showed that, although it is possible, by feeble illumination and other unfavourable external factors, to hinder the formation of the flat surface, the latter always arises under normal conditions in germination in water just as it does on soil.

Until recently it was supposed that *Sphagnum* lacked the capacity for producing "secondary" protonema which is possessed by probably all other mosses. By secondary protonema is meant protonema which grows out from isolated portions of a moss-plant, and which gives rise to new plants, thus serving for asexual reproduction. In 1898, however, Oehlmann showed that this view is incorrect, and that it arises from the fact that *Sphagnum* apparently does lack the power, shown by many mosses, of producing protonema from *any* living cell of the plant, but that the difference between *Sphagnum* and other mosses in this respect is more apparent than real. In other words, in *Sphagnum* this power to reproduce the plant through the intermediation of protonema appears to be confined to certain definite portions of the plant. It is possessed

chiefly by the tissue of the young branches at the top of the plant, where the tissue remains for a long time in an active condition. On cutting off a young branch, or chopping it into pieces, protonema grows out from the cells adjoining the injured region, including those of the stem itself and of the bases of the leaves. In some cases, Oehlmann was able to induce the production of protonema by older parts of the plant, from living cells in the stems of both the main axis and the branches, and even from the narrow green cells in the upper part of a mature leaf, just above the place where the leaf had been cut across when removed from the plant. It would appear, in fact, that under favourable conditions *any* living cell of the *Sphagnum* plant might be stimulated to produce protonema, and that the supposed absence of this power is owing to these conditions not having been fully investigated. Oehlmann also found that in some of his cultures of isolated stems and leaves, or stem-fragments and leaf-fragments, there grew out from the regenerating tissue, young leafy *Sphagnum* plants without the intervention of protonema; sometimes these young plants were accompanied by thread-like and flattened protonema, all arising from the same spot.

The young *Sphagnum* plant, whether arising from primary protonema (in the germination of the spore), or from secondary protonema (in regeneration of portions of the mature plant), bears rooting hairs which fix it to the soil and enable it to absorb water and dissolved salts, and sometimes these hairs are seen twining like tendrils around branches of old *Sphagnum* plants among which the spores have germinated. As the plant develops, however, it produces no more rooting hairs, and these are quite absent from the mature plant; from the mode of life of *Sphagnum* it is obvious that such absorbing hairs are unnecessary, since the plant has such efficient means for the absorption of water in its remarkable capillary branch-system and its perforated hyaline cells.

QUERIES AND ANSWERS.

Readers are invited to send in Questions and to answer the Queries which are printed on this page.

QUESTIONS.

2. Still remains unanswered. (See page 288 in the July number of "KNOWLEDGE.")

3. BAROMETER READINGS.—Can any of your subscribers inform me if the barometer has ever given a reading of over 31 inches. I have particulars of several registrations between 30·7 and 30·9, but I have had it asserted that it has been read above 31, and that it may even go up to 32 inches, which I have questioned, but am unable to find the necessary figures, in any book I have, giving the basis on which I can verify the above one way or the other.

Should there have been any readings above 31 inches, I should feel obliged by the particulars of places and dates when and where the observations were made.

WM. S. JEFFERY.

4. THE FERTILISATION OF QUEEN WASPS.—Can you tell me whether the destruction of queen wasps in the spring and early summer influences the number of wasps produced in August? I cannot ascertain from any of my books when or how the queens are fertilized, nor when they lay their eggs. It must be well known whether the queens are fertilized before or after hibernation. If before, their destruction would not necessarily lessen the number of wasps produced unless their care were necessary to the process of hatching and feeding the larvae. A good deal of doubt exists on this subject, and the facts might be of interest to many of your readers.

JOHN GLAS SANDEMAN.

5. STAR MAP OF THE NORTHERN HEMISPHERE.—Is there a single map showing all the constellations which we see in our Northern Hemisphere, just their positions at some stated time, so that I can see on it where, say, Orion is at the present time? I know of course where they are, but I want to point them out to our school children.

T.M.

6. INTENSIFICATION WITH MERCURY AND FERROUS OXALATE.—Many of your readers, who, like myself, are occupied with photography, must have read with great interest the paper on intensification by Mr. Chapman Jones. The process recommended is the mercury and ferrous oxalate method. I think many of your readers, like myself, would be glad of a detailed description of this process, with formulae, or, if this would take up too much space in your paper, a reference to a book or publication where this can be found.

EDMUND GILES LODER, F.R.A.S.

[NOTE.—Mr. Chapman Jones in the Photography Column of this month's "KNOWLEDGE," has given an account of intensification with mercury and ferrous oxalate, to which we refer Sir Edmund Loder.—EDS.]

REPLIES.

1. In reply to a query in the July number of "KNOWLEDGE," *Asterosporium hoffmani* may be found in January and February on fallen branches of beech. It does not appear to be very common. The closely related *Coryneum* and *Prosthemium* are also to be found about the same season. It is a pity that the time of appearance of most fungi is not recorded in the books describing them; but the whole subject is in such a state of transition that any definite classification, or information regarding time of appearance is scarcely to be looked for at present. If the enquirer has not seen *Asterosporium*, probably I can supply a specimen if he will communicate with the Editor, who will no doubt kindly forward his communication to me.

J.B.

XUM

THE FACE OF THE SKY FOR AUGUST.

By W. SHACKLETON, F.R.A.S., A.R.C.Sc.

THE SUN.—On the 1st the Sun rises at 4.25 and sets at 7.48; on the 31st he rises at 5.11 and sets at 6.49. Sun spots are not very numerous; small groups are occasionally visible on the solar disc.

The positions of the Sun's axis, centre of the disc, and heliographic longitude of the centre are given in the following table:—

Date	Axis inclined from N. point.	Centre N. of Sun's Equator.	Heliographic Longitude of Centre of Disc.
Aug. 4 ...	11° 57′E	6° 3′	113° 22′
,, 9 ..	13° 51′E	6° 22′	47° 15′
,, 14 ...	15° 39′E	6° 38′	341° 9′
,, 19 ...	17° 20′E	6° 52′	275° 4′
,, 24 ...	18° 54′E	7° 2′	208° 59′
,, 29 ..	20° 20′E	7° 9′	142° 56′
Sept. 3 ...	21° 38′E	7° 14′	76° 53′
,, 8 ...	22° 47′E	7° 15′	10° 52′

THE MOON:—

Date.	Phases.	H. M.
Aug 5 ...	● New Moon.	6 37 a.m.
,, 13 ..	☽ First Quarter.	2 1 a.m.
,, 20 ...	○ Full Moon.	7 14 p.m.
,, 27 ..	☾ Last Quarter.	2 33 p.m.
Sept. 3 ...	● New Moon.	6 6 p.m.
Aug. 12 ..	Apogee	6 36 p.m.
,, 25 ..	Perigee	1 12 a.m.
Sept 9 ..	Apogee	1 48 p.m.

OCCULTATIONS.—The following occultations are visible from Greenwich before midnight:—

Date.	Star's Name.	Magnitude.	Disappearance.		Reappearance.	
			Mean Time.	Angle from N. point. E.	Mean Time.	Angle from N. point. E.
			a.m.		a.m.	
Aug 20	35 Capricorni	6·0	1.4	98°	2.1	209°
,, 26	14 Tauri	6·2	2.47	26°	3 42	281°
,, 28	τ Tauri	4·3	2.11	117°	2.54	201°
			p.m.		p.m.	
Sept. 14	ω Sagittarii	4·8	6.5	68°	7.23	276°
,, 14	A Sagittarii	4·9	7.56	68°	9.15	265°

THE PLANETS.—Mercury (Aug. 1st, R.A. $9^h\ 38^m$; Dec. N. 15° 46′; Sept. 1st, R.A. $12^h\ 15^m$; Dec. S. 4° 25′) is an evening star in Leo, setting about 8 p.m. on the 15th. The planet is at greatest elongation of 27° 13′ E. from the Sun on the 30th, but the elongation is an unfavourable one, and the planet will be difficult to observe.

Venus (Aug. 1st, R.A. $6^h\ 37^m$; Dec. N. 22° 32′; Sept. 1st, R.A. $9^h\ 15^m$; Dec. N. 16° 43′) is a morning star in Gemini, very little observable, as she rises in the N.E. about 2.15 a.m., on the 15th. The apparent diameter of the planet is 11″, and 0·9 of the disc is illuminated, that is, it appears slightly gibbous when viewed in the telescope.

Mars (Aug. 1st, R.A. $9^h\ 59^m$; Dec. N. 13° 31′; Sept. 1st, $11^h\ 13^m$; Dec. N. 6° 6′) is not observable, as he sets shortly after the sun throughout the month.

Pallas (Minor Planet) (Aug. 1st, R.A. $22^h\ 10^m$; Dec. N. 11° 4′; Sept. 1st, R.A. $21^h\ 48^m$; Dec. N. 6° 13′) is in opposition to the Sun on August 26th; about this time, therefore, the asteroid attains its maximum luminosity, being of magnitude 8·0, and is due South at midnight. The planet is describing a retrograde path not far from θ Pegasi, and although not visible to the naked eye, it can be detected in small telescopes by its motion among the stars if observations are made on successive nights.

Jupiter (Aug. 1st, R.A. $12^h\ 37^m$; Dec. S. 2° 41′; Sept. 1st, R.A. $12^h\ 57^m$; Dec. S. 4° 51′) is almost inobservable, being low down in the West at sunset. The planet sets on the 1st at 9.50 p.m. and on the 31st at 8 p.m. No satellite phenomenon is observable this month, as the planet appears in too bright a portion of the sky. The planet is situated about 2° S. of the binary star γ Virginis, and the Moon appears near the planet on the evening of the 9th.

Saturn (Aug. 1st, R.A. $2^h\ 19^m$; Dec. N. 11° 16′; Sept. 1st, $2^h\ 20^m$; Dec. N. 11° 11′) is well placed for observation, being situated in Aries and rising about 9.30 p.m. on the 18th. Towards the end of the month the planet may be observed looking due East at 10 p.m. and a few degrees above the horizon; he appears as a bright star shining with a leaden hue. The telescopic view of the planet is extremely fine on account of the ring encircling the planet, and a good view may be obtained in small telescopes of about one-and-a-half inches aperture, if the object glass is good and the instrument is held steadily. A magnifying power of about fifty is sufficient to show the ring, but a greater magnification is required to see the belts on the disc, as they are not so conspicuous as those on Jupiter. The ring appears well open, the plane of the ring being inclined to our line of vision at an angle of 18°; the southern surface is visible. The diameters of the outer major and minor axes of the outer ring are 43″ and 13″·5 respectively, whilst the polar diameter of the ball is 17″·5. The planet is stationary on the 20th, after which his motion is retrograde or westerly. The Moon appears near the planet on the evening of the 25th.

Uranus (Aug. 15, R.A. $19^h\ 36^m$; Dec. S. 22° 9′) though somewhat low down in the sky, is well placed for observation during the early evening, the planet being due South on the 15th at 10.2 p.m. He is situated about 5° S.W. of α and β Capricorni. Uranus is just perceptible to the naked eye, but can easily be seen with a pair of opera glasses. The diameter of the disc is nearly 4″, and the colour is greenish. As seen in large telescopes the planet appears more luminous at the centre of the disc than at the limb—somewhat similar to Jupiter and Saturn.

Neptune (Aug. 15th, R.A. $7^h\ 27^m$; Dec. N. 21° 17′) does not rise until after midnight, and is practically inobservable.

METEORS :—

Date.	Radiant.		——
	R.A.	Dec.	
	h. m.		
Aug. 10-12 ..	3 0	N. 57°	Great *Perseid* shower; radiant moving E.N.E. about 1° per day.
,, 15-25 ...	19 24	N. 60°	*o* Draconids; bright slow meteors.

The *Perseid* shower lasts nearly all the month, the earth encountering the densest portion of the swarm about the 11th; the radiant then being near η Persei. The meteors are quick with yellowish streaks.

Minima of Algol occur on the 8th at 9.10 p.m., and on the 28th at 10.53 p.m.

Mira (*o* Ceti) is due at maximum on August 3rd, but as the exact date is somewhat uncertain, observations should be continued for some time after this date. The mean period is about 331 days. The star is also remarkable for its spectrum, which may be well observed in a 3-in. telescope, using a Maclean or Zollner spectroscopic eyepiece; the spectrum consists of broad dark bands, in which bright lines, due to hydrogen, occur.

TELESCOPIC OBJECTS :—

DOUBLE STARS.—Polaris, mags. 2·1, 9·5; separation 18″·6. The visibility of the small star is used as a test for a good 2-inch object glass.

σ Scorpii, R.A. $16^h\ 15^m$; S. 25° 22′; mags. 3·0, 7·6; separation 20″·6.

ζ Sagittae, R.A. $19^h\ 45^m$; N. 18° 54′; mags. 5·7, 8.8; separation 9″·0; colours, white and blue.

α^1, α^2 Capricorni, R.A. $20^h\ 13^m$; S. 12° 50′; mags. α^1 4·5 α^2 3·8; naked eye double; separation 373″; very easy with opera glasses.

γ Delphini, R.A. $20^h\ 42^m$; N. 15° 46′; mags. 4·1, 5·0; separation 10″·8; very pretty double for small telescopes; colours, orange and light green.

NEBULA, &c.—Dumb Bell nebula in Vulpecula, nearly 4° due North of γ Sagittae. Rather faint object in a 3-inch telescope.

(M8) Cluster in Sagittarius; large luminous field of small stars; fine object in a pair of field glasses. About a degree E. of the star 4 Sagittarii.

SOLAR DISTURBANCES DURING JUNE, 1910.

By FRANK C. DENNETT.

The month of June shows a falling off in the amount of disturbance on the sun, being on the 21st and 22nd only faculae visible. The longitude of the central meridian on June 1st, at noon, was 240° 18′.

Nos. 44 and 46 of the May list continued on the disc until June 3rd and 5th respectively, and so are shown on the accompanying chart.

No. 47.—On 3rd a faculic area within the eastern limb contained two pores, on 6th only one spotlet, the site being marked on 7th by a tiny group of penumbraless pores. A spotlet nearly 4,000 miles across, with some tiny dots near by, on morning of 8th, but the pores were gone by the afternoon, and the spot was not seen after.

No. 48.—When first seen, on 9th, it was a spot 5,000 miles in diameter, east of a very faculic district, but dwindled until on 13th only two pores remained, one continuing until 14th.

No. 49.—On 11th a spotlet was seen south-east of the last, which by next day had dwindled to a pore, not seen after.

No. 49a.—A dark pore with a hazy companion appeared on 16th close to the central meridian, but was not seen again.

No. 50.—A pair of spotlets 10° south latitude, about 11,000 miles apart on 17th, minute pores nearly outlining an ellipse. Only one remained until 18th. A pore showed again on 20th, amid the faculae within the western limb, but was not seen again.

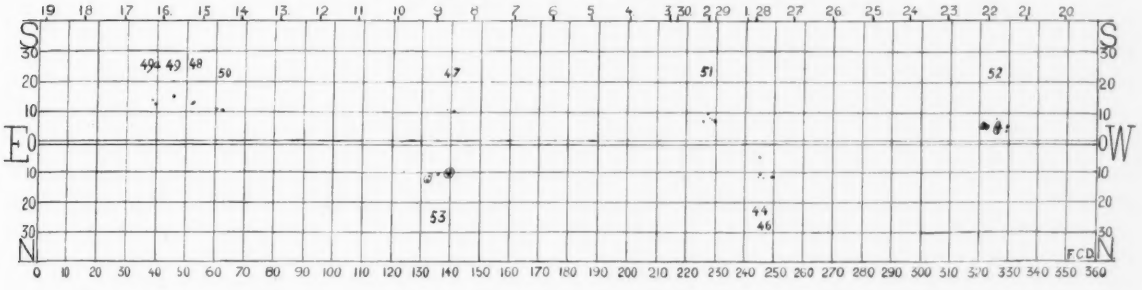
No. 51.—A spotlet in a faculic area within the eastern limb on 23rd, with a dull patch just south. The pores composing this group were constantly changing their configuration, and the greatest length was 32,000 miles. Last seen as a pair of pores on 30th.

No. 52.—A group of pores first seen in the afternoon of 25th. On 26th the group presented a somewhat singular appearance; the middle spot showed almost continuous penumbra for about 26,000 miles north to south, and quite so for 15,000 miles, the length of the group being 75,000 miles. On 27th the proportion of dark umbra had increased, and when last seen, close to the east limb on 28th, there appeared to be a triangle of three spots.

No. 53.—Two small spots surrounded by faculae first seen within the eastern limb on 30th. On July 1st a pore showed between the spots, the western one having two umbrae. The leader first extended eastward, then increased in size to 20,000 miles in mean diameter, whilst the eastern spot dwindled and was last seen on 7th. A pore showed close behind the leader on 8th, but not after. As the big spot neared the western limb, on 11th-12th, it appeared to have broken into two spots in a cloud of faculae. The group became 60,000 miles in length, and on 7th and 8th the penumbra of the leader had the edge bordering the umbrae brightly fringed.

The chart is made from combined observations of I. McHarg, A. A. Buss, E. E. Peacock, W. Strachan and F. C. Dennett.

DAY OF JUNE.



NOTES ON BRITISH FORAMINIFERA.

II.—MASSILINA SECANS, D'ORBIGNY, SP.

By EDWARD HERON-ALLEN, F.L.S., F.R.M.S., AND ARTHUR EARLAND.

THE most conspicuous, and by far the commonest species to be found in almost any shore-gathering made round our Southern or Western coastline is the handsome Miliolid to which we devote the present article. *Massilina secans* varies in abundance in different localities, but, owing to its large size, wherever it occurs in any profusion it immediately attracts attention. Down the Channel, where shore-gatherings are usually more or less black in colour, owing to the deposition of coal dust and ashes from ships, its large white shells are easily visible to the naked eye against their dark back-ground. In the Channel Islands we have seen large patches of the yellow beach sand whitened with a compact layer of its shells. But for its acme of abundance we must travel to the western shores of Ireland, where at Dog's Bay, and other similar localities, its shells are deposited on the sands, with other foraminifera, in such prodigious numbers that they are blown up the beach by the prevalent wind, to build up extensive banks or dunes above high-water mark, thus forming a true sub-aërial organic deposit.

From a photograph *by Arthur E. Smith.*

FIGURE 1.

Massilina secans d'Orbigny, sp.

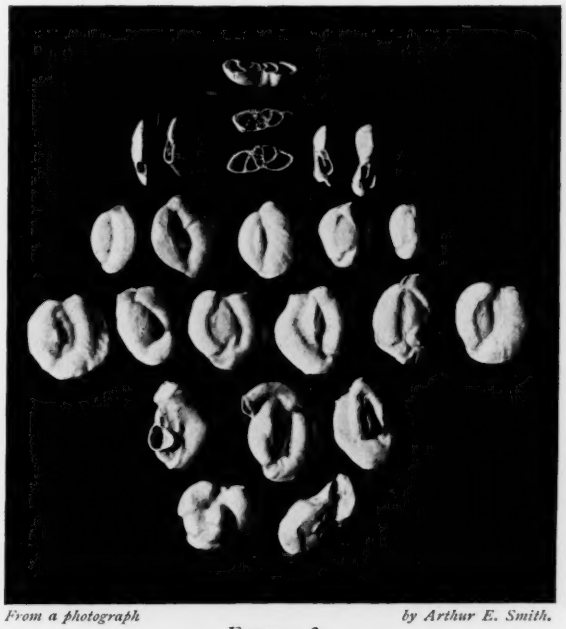
A specimen viewed as a transparent object with dark ground illumination. × 75 diameters.

Viewed with an ordinary pocket lens, the shell of *Massilina secans* is seen to be a smooth and porcellanous, lenticular in shape, and composed of a number of elongated chambers laid round a longitudinal axis. The later chambers envelope the earlier ones inaequilaterally, so that as a rule only two or three chambers are visible on one side of the shell, while on the other, three, four, or even more chambers may be seen. At the extremity of the last chamber is the solitary aperture, usually furnished with a prominent tooth. Through this aperture the protoplasm of which the animal consists exudes, and extends into long transparent filaments or *pseudopodia*, which are typically *reticulate*, i.e., they mesh together irregularly, anastomosing with one another. Throughout the whole network, when the specimen is viewed under a moderately high power of the microscope in a cell with sea water, the process known as the "streaming" of the protoplasm may be seen. This consists of a definite current in the protoplasm running up one side of the filament and down the other, and is doubtless connected with the feeding of the animal, as small particles of organic matter entangled in the protoplasm can be seen to travel up the pseudopodium towards the aperture of the shell. The movement is seen at its best by means of dark-ground illumination.

When a gathering of living Foraminifera has been made by washing seaweed in the manner described in our last paper, and the residuum of mud has been allowed to settle in the tanks around a few fronds of growing *Ulva* or *Cladophora*, the first Foraminifer to work its way to the surface of the mud, and to make its appearance by crawling up the glass side of the tank on to the stones projecting above the mud, or up the fronds of the weed, will be *Massilina secans*. It may also be observed that in the event of anything going wrong with the tank, and after the more delicate forms have disappeared, the last species in evidence will also be *Massilina secans*, which appears to flourish under circumstances which cause less hardy species to remain dormant in the mud, or even die.

The specimens adherent to the glass will be found, as a rule, to be attached by the oral (or aperture) end, the pseudopodia extending in all directions along the surface of the glass. The shell is thus supported at right angles to the glass, showing the aperture and the tooth or valve by which it is partially closed and protected. As one watches it under a lens or low power objective, the entire shell may often be seen to squirm about on the pivot of its

aperture, revolve, or even travel for a short distance, the animal pulling itself along by means of its pseudopodia, which we have seen extended to a distance equal to three, four or even five times the length of the shell itself. Now and then a minute organism such as a monad, an infusorian, or a diatom is seen to be caught in the meshes of the network of pseudopodia, and if closely watched will be seen to disappear, enveloped in the protoplasm. So far as our observations go, such comparatively large objects are not carried down towards the aperture with the stream of protoplasm. They are probably absorbed and digested outside the shell. In this place it may be remarked that in nearly all cases, whether *Massilina* is attached to the glass, to the rocks, or to the weed, it carries with it round the aperture a concretion of mud varying in size, in which, so to say, its nose is buried, and through which the pseudopodia extend. This muddy concretion is no doubt closely incorporated with the protoplasm, for it cannot be detached with either brush or needle point without dislodging the shell from its position, and tearing it away from the extended pseudopodia. The mud is no doubt an excretion of argillaceous matter, originally in suspension or solution in the sea water, and separated therefrom by the pseudopodia in the quest for food.



From a photograph *by Arthur E. Smith.*

FIGURE 2.

Massilina secans, d'Orbigny, sp.

The two middle rows are normal specimens and the two lower rows abnormal and distorted forms. The uppermost examples show the aperture and the arrangement of the chambers as seen in sections of the shell. × 54 diameters.

There is no evidence whatever, so far as we are aware, that the pseudopodia of Foraminifera possess any active functions for attack or defence, or lethal powers similar to the *acontia* of the Sea-Anemones (Sagartidae), but we have frequently seen small Copepoda blunder into the pseudopodial net of a *Massilina*, and to all appearance be instantly paralysed, either remaining enmeshed in the pseudopodia, or falling motionless to the bottom of the tank. In the latter case after about ten minutes the Copepod revives and swims away, but in the former we have seen it die and turn white and opaque before the pseudopodia released it, whether after having provided a full meal for the *Massilina* or not, we cannot say.

Massilina secans, when thus examined in the living state, appears to be comparatively indifferent to damage. We have, in the attempt to dislodge a shell for closer examination, smashed the last, or the penultimate chamber. In the former case the pseudopodia were soon extended from the point of fracture, and in the latter from the end of what would have been the last chamber, if its growth had been checked at that point. It is a common thing to find a living *Massilina* whose shell has thus been broken and repaired by the secretion of a new shell over the protoplasm, protruded at the point of fracture. This habit of repair probably accounts for the majority of the abnormal and contorted specimens—sometimes possessing two or three independent apertures—which are to be found in any extensive Milioline gathering.

As usual, whenever a species occurs in any abundance, abnormal or distorted specimens are of frequent occurrence. Apart from such, of which we figure a few specimens, there are two well marked varieties of *Massilina secans*, both of extremely rare occurrence, to be found in Great Britain. In the first (*Massilina secans*, d'Orbigny sp., variety *denticulata*, Costa), the outer margin is produced into an elegantly scalloped keel. In the other (*M. secans*, var. *tenuistriata*, Earland), the usually smooth shell surface is covered with very fine striae, running parallel to the long axis of the chambers. Probably both varieties are to be found wherever an extensive series of specimens is examined, but at present the only British record for either is from the shore sand of Bognor, Sussex.* The variety *denticulata* is fairly common in some Mediterranean gatherings.

Massilina secans is a typical Foraminifer of warm and temperate seas, and it would be very interesting to have more information as to the limits of its distribution in the North Sea. Brady reports that it is generally distributed round our coast. We have ourselves found it at Kingsgate in the Isle of Thanet, but not at Herne Bay, and, so far as we know, there is no published record on the South Coast, east of Bognor, where it is abundant. No doubt it does occur eastward of this point, and at other

* The Foraminifera of the Shore Sand of Bognor, Sussex. A. Earland, 1905, *Journal Quekett Micros. Club*, Ser. II, Vol. IX, No. 57. Both varieties are figured in this paper.

XUM

localities on the East Coast of Great Britain. But how far northwards does it extend? We are convinced, from the examination of a large quantity of shallow water dredgings, that it does not occur in the North Sea between the Firth of Forth and the Pentland Firth, in the extreme North of Scotland, although it is abundant in some Orkney and Shetland gatherings. The presumption is that the species has extended its range in comparatively recent geological times, since the formation of the English Channel, and has travelled Northwards with the warm Atlantic water, *via* the West Coasts of Ireland and Scotland. Perhaps some readers of "KNOWLEDGE" may avail themselves of the opportunity of clearing up this point, by making gatherings on the eastern shores of our islands.

As might be expected from its abundance and conspicuous size, *Massilina secans* was one of the earliest Foraminifera to be identified when these little organisms began to be studied at the end of the 18th century, and its subsequent history is a very good example of that laxity of varying nomenclature, which vexes the soul of the student of the Foraminifera and often causes him to wish for a clean slate on which to work. Soldani, in his curious *Testaceographia* published in 1795, figures it with other Miliolidae under the name "Frumentaria *seminula*." As, however, Soldani did not adopt the Linnean system, his record has only an antiquarian interest, and the species remained undescribed until 1826, when d'Orbigny published his *Tableau méthodique de la classe des Cephalopodes*. In this historic publication he gave two separate names to our friend, viz., *Quinqueloculina secans* and *Q. vulgaris*, and in subsequent years, with characteristic lavishness, he rechristened it in several different publications. As, however, he published a model of *Quinqueloculina secans*, and none of *Q. vulgaris*, the first specific name has survived.

A reference to the Bibliography at the end of this paper, which makes no pretensions to finality, will be sufficient to illustrate some of the vicissitudes of nomenclature through which our species has passed. Williamson's genus *Miliolina* absorbed the d'Orbignyan genera *Triloculina* and *Quinqueloculina*, and for many years the subject of our note was universally recorded as *Miliolina secans*, d'Orbigny, sp. The researches of Schlumberger and others, based on the arrangement of the chambers of the Miliolinae, as seen in thin sections of their shells, has led to a general re-arrangement of the group which is still in progress, and in which, as in a game of musical chairs, our species seems to be continually changing its place. Schlumberger in the first place allotted it to his sub-genus *Sigmoilina*, in which a transverse section shows the chambers arranged in a sigmoidal curve. Later on he transferred it to his sub-genus *Massilina*, which is characterised by a quinqueloculine arrangement of the earlier chambers, followed by a series of chambers arranged in one or two planes. Here for the present it remains, and as *Massilina secans*, d'Orbigny, sp., it must be recorded until, as is not unlikely in our opinion, an extended knowledge of the subject sweeps these seemingly artificial sub-generic distinctions away, and Williamson's genus *Miliolina* is re-constituted, to include all the Miliolininae.

BIBLIOGRAPHY.

"Frumentaria *seminula*," Soldani, 1795, Testaceographia, vol. i, pt. 3, p. 228, pl. clii, fig. E.

Quinqueloculina secans, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii, p. 303, No. 43; Modèle No. 96.

Quinqueloculina vulgaris, d'Orbigny, 1826, Ibid p. 302, No. 33.

Quinqueloculina secans (d'Orbigny sp.), Roemer, 1838, Leonh. u. Bronns Jahrb., p. 393, pl. iii, fig. 77.

Quinqueloculina planciana, d'Orbigny, 1839, Foram. Cuba, p. 162, pl. x, figs. 24, 25.

Quinqueloculina cora, d'Orbigny, 1839, Foram. Amér. Mérid., p. 76, pl. ix, figs. 16-18.

Quinqueloculina haidingerii, d'Orbigny, 1846, For. Foss. Vienne, p. 289, pl. xviii, figs. 13-15.

Miliolina seminulum (Linné sp.), var. *disciformis*, Williamson, 1858, Recent Foram. Gt. Britain, p. 88, pl. vii, figs. 188, 189.

Quinqueloculina secans (d'Orbigny sp.), Parker, Jones and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol. xvi, p. 34, pl. i, fig 10.

Miliolina secans (d'Orbigny sp.), Brady, 1884, Foram. Challenger Expedn., p. 167, pl. vi, figs. 1, 2.

Miliolina secans (d'Orbigny sp.), Sherborn and Chapman, 1886, Jour. R. Mic. Soc., ser. 2, vol. vi, p. 742, pl. xiv, fig. 4.

Miliolina secans (d'Orbigny sp.), Brady, 1887, Synopsis of British Foram., Jour. R. Mic. Soc., pt. 6, p. 882.

Sigmoilina secans (d'Orbigny sp.), Schlumberger, 1887, Note sur le genre *Planispirina*, Bull. Soc. Zool. France, vol. xii, p. 118.

Massilina secans, (d'Orbigny sp.), Schlumberger, 1893, Mil. golfe Marseille, Mém. Soc. Zool. France, vol. vi, p. 218, pl. iv, figs. 82, 83.

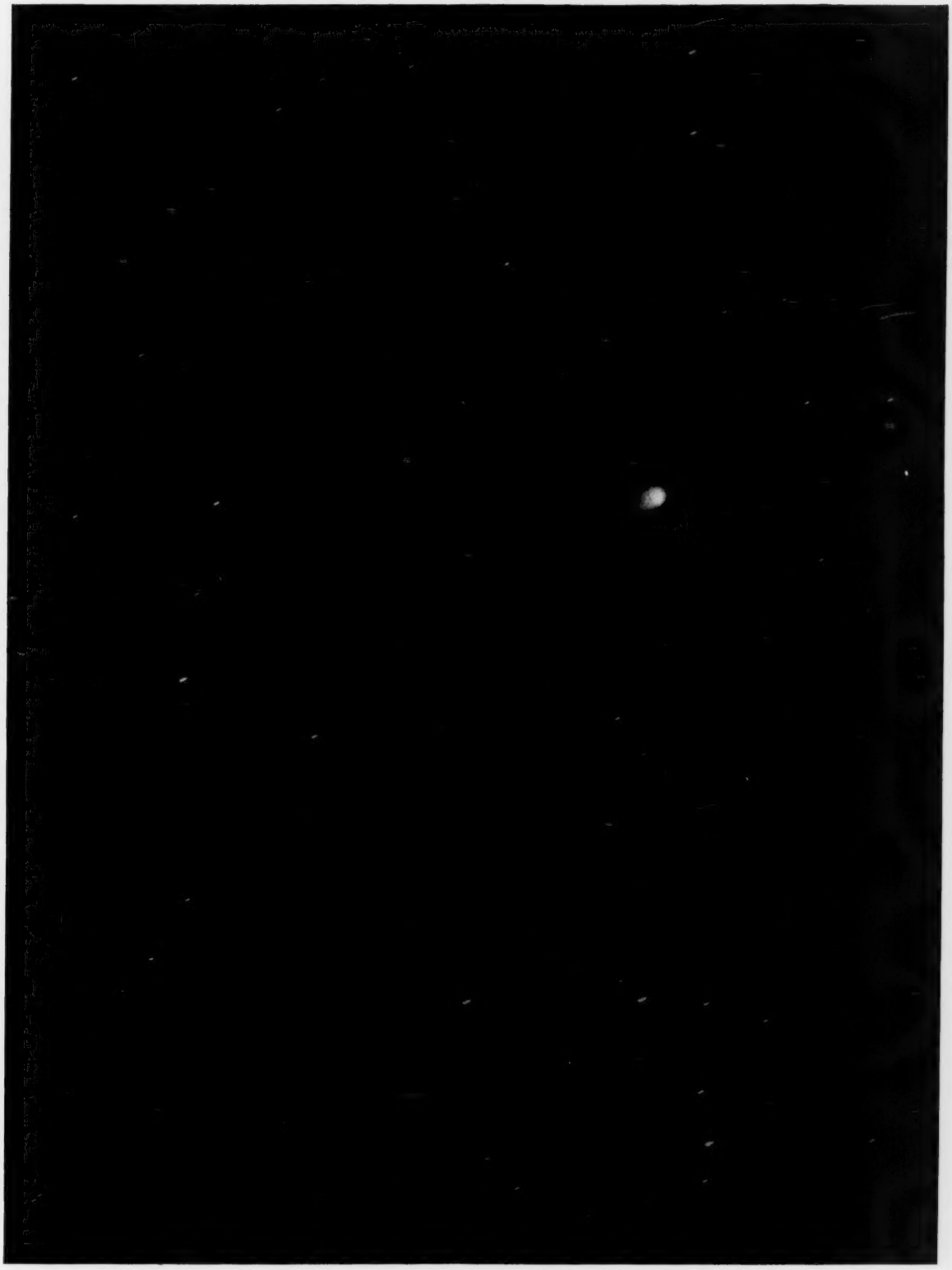
Miliolina secans (d'Orbigny sp.), Goës, 1894, Arctic and Scandinavian Foram., Kongl. Svenska Vet. Akad. Handl., Bd. xxv, No. 9, p. 112, pl. xx, figs. 856, 856g.

Massilina secans (d'Orbigny sp.), Earland, 1905, Jour. Quekett Mic. Club, ser. 2, vol. ix, No. 57, pp. 197, 198, pl. xi, figs. 4, 5.

HALLEY'S COMET; DESCRIPTION OF PLATE.

Through the courtesy of Mr. H. Connell we are able to reproduce a photograph of Halley's Comet taken by him and Messrs. Taylor and Woodhouse on a six-inch Cooke photovisual telescope and mounting at the Presidency College, Calcutta, on May 28th, 1910. An "Eastman" plate was used, the aperture of the lens was f.4, and the exposure forty minutes, namely from 8.40 to 9.20 p.m. (See next page).

To face page 306.



From a photograph *by Messrs. Taylor, Connell & Woodhouse.*

Halley's Comet as seen at Calcutta on May 28th, 1910.

XUM

CORRESPONDENCE.

HEREDITY AND TRADITION.

To the Editors of "KNOWLEDGE."

SIRS,—An important point, which I have been endeavouring to emphasise for some time past, has arisen in the course of the recent correspondence in the press on the subject of Heredity and Tradition.

It is one which affects the physicist perhaps even more deeply than it does the biologist, who is concerned chiefly with the visible forms of living matter, and regards the invisible as beyond his ken.

In fact, it is only fair to say that with the exception of Sir Edwin Ray Lankester, Sir Francis Galton and Dr. Mercer, I do not know of any biologists who have entered into the question or shown any inclination to appreciate its importance. I mean the difficulty which Clerk Maxwell long ago pointed out must necessarily be encountered in the way of explaining, on the atomic hypothesis, the vast and complicated mechanism of a living organism; when we bear in mind the comparatively small number of atoms in the nucleus of the living cell; and the still smaller number at our disposal since his day in the determinants of the germ-plasm,—a few thousand atoms at the most. This difficulty becomes the more embarrassing as heredity takes place throughout countless generations, from germ-plasm to fully developed organism, through germ-plasm again to fully developed organism, in an indefinite number of ever-recurring cycles, *ad infinitum*. A strange confusion may be pointed out here,—as it seems to exist in the minds of many biologists,—between the extremely intricate atomic mechanism of inheritance, and the variations which can arise from the permutations and combinations of a few units, as illustrated by the analogy of the formation of words and sentences from the few letters of the alphabet. [See Francis Darwin's Presidential Address, British Association, Dublin, 1908.] For the difficulty as regards the mechanism of heredity is quite distinct, and of a totally different nature from, that of variations in certain features of that mechanism.

There is no doubt that all the variations of living organisms past, present and to come, throughout nature can be accounted for by mere permutations and combinations of a few determinants of germ-plasm. But the inherent mechanism of its structure and properties, in each case actual and potential, in any particular organism does not appear to admit of any such explanation. (See Clerk Maxwell, "Atom," Collected Works, and Encyclopaedia Britannica, ninth edition). And so we are led, I think, to infer the existence of biological properties in the atoms themselves, as distinct from their mere chemical and physical attributes, and, for aught we know, in the electron and still smaller bodies, *ad infinitum*, until we reach the constituent particles of the aether (see Articles headed "Physics and Biology," "KNOWLEDGE," March and April, 1907); which I regard as monads of the aether.

I may add, in conclusion, that the tendency for traditional superstitions and beliefs, which led up to this discussion, and the consequent beliefs which result from sentiments and emotions and other tendencies, such as credulity, awe, fear, and so forth, is all that is hereditary in the case of such beliefs; not the beliefs themselves, which are handed down by tradition as language is. But the capacity for language is perhaps the greatest of them; as it is also the most wonderful. And I do not see, nor do I know any physicist who does, how any such inherited mechanism of potential qualities can be handed on from generation to generation, by germ-plasm, in an indefinite series, by mere atomic permutation and combination, as the biologists suppose, without postulating that the atoms themselves are possessed of biological potentialities; and that these are the results of dynamical processes in still smaller particles.

I am, Sirs,

Faithfully yours,

JOHN BUTLER BURKE.

68, BUCKINGHAM GATE, S.W.

June 24th, 1910.

SCIENTIFIC LATINITY.

To the Editors of "KNOWLEDGE."

Sirs,—Mr. Stebbing is evidently quite aware of the shocking character of his proposal; science is not affected by aesthetic considerations. The barbarisms that are in common use as technical terms sufficiently prove that. Certain frequently recurring mispronunciations indicate the extinction of the study of Latin and Greek verses. These things apparently do not matter, for we are all for utility. On the ground of utility, therefore, I beg to oppose the change.

The absurdities which Mr. Stebbing has gibbeted may all be removed by the help of a Latin Dictionary and Roby's Grammar. Is it too much to expect that the man of science should include these amongst the pieces of apparatus with which he is expected to be conversant? In the course of a scientific education he becomes acquainted with many things much more remotely connected with the main object of his studies. If, however, the Central Fount of Authority should definitely decide that there is to be "no more Latin, no more Greek," then it will for some time at least be possible to hire, at an exiguous stipend, some of the quondam professors of those languages, who will be able to introduce the necessary corrections; they should be promptly discharged on attaining the age qualifying them for Old Age Pensions. Thus decency might be preserved; for surely, sirs, we ought not to misrepresent the dead languages, in addition to burying them.

There is a kind of pleasure, with which Mr. Stebbing himself is no doubt acquainted, in reading over ancient books of science expressed in the Latin tongue. It may not be said that their style is always Ciceronian; yet it has a kind of dignity; and it had utility, for all its readers understood it. Some men are sometimes tempted to wish that their German and Japanese correspondents would make use of the Latin tongue. They tell us that Esperanto will eventually be used for scientific purposes; but, unfortunately, Esperanto is *not* a dead language, but shows a rather disturbing tendency to evolve new conventions. I cannot help thinking that Latin might again be used for scientific communications, with great advantage to the whole scientific world. Probably the custom would never have died out, had it not been for the morbid sensitiveness to minute improprieties which is induced by too scholastic a view of the language. There is plenty of good useful Latin which does not violate the concords, though it has no hesitation in borrowing words and making new ones when necessary; it was good enough for the great founders of modern science, though of course to the man who lives for

XUM

pure language alone it is dog Latin. That is the origin of these difficulties; you take a good thing, like the Latin language (other matters might be mentioned in the same place); you detach it from its functions, and set it up on a pedestal as an object of worship; and the result is that it loses its own proper force and goodness.

The moral seems to go further than the immediate object demands; Mr. Stebbing will doubtless rejoin that all who philosophise should be condemned to philosophise in Greek. I am quite of that opinion; let any man read Euclid's Elements in Greek, and he will not fail to notice that it is more interesting and lucid than any translation. But meanwhile, though atmospheric conditions prevent our making hay out of doors, let us not make hay of the Latin genders. Yet, again, they may assist us in steering our way through complicated descriptions.

Yours,
E. W. BOWELL.

PENSHURST.
July, 1910.

APPEARANCE PRESENTED BY THE SUN DURING THE TRANSIT OF HALLEY'S COMET, MAY 18TH, 1910.

To the Editors of "KNOWLEDGE."

SIRS,—On the 18th of May, between 5 and 5.30 p.m., we were at Barbados. Mrs. Guppy was just starting for a walk along the Bay Road when her attention was called by the cries of people to the extraordinary appearance presented by the sun. She called me and I ran out of the house to see what caused the commotion.

All along the western horizon, above the ocean, lay a thick bank of rain clouds the upper edge of which thinned off into lighter clouds above. In the thinner part of the cloud bank, and apparently at an elevation of about 12° to 15° above the sea horizon the sun was visible just sufficiently obscured to enable one to look at it without much pain. Its disk was covered with coruscations of purple, orange and yellow which passed over its surface in large undulations. All about the neighbourhood of the sun, the clouds were of a pinkish tinge. This appearance lasted about half-an-hour, when it gradually passed off as the sun sank beneath the heavy bank of clouds. An idea of the appearance of the sun might be formed by likening it to a fierce bush fire burning on the ridge of a hill except that the colours were not the same.

I imagine that this phenomenon took place when the earth was in the Comet's tail. The time was about nine hours Greenwich mean time onwards. The sun was within an hour of setting, and the visibility of the phenomenon was in some measure due to the bank of clouds.

Yours faithfully,
R. J. LECHMERE GUPPY.

41, OXFORD TERRACE,
LONDON, W.
July, 1910.

ASTRONOMICAL SUPERSTITIONS.

To the Editors of "KNOWLEDGE."

SIRS,—I have just read, in your February issue, your correspondents' views of the letters published in the preceding number *anent* the article "Astronomical Superstitions." It seems to me that the charge of bigotry made in one of them is unjust. In the article Mr. Dean asserted, on the authority of Mark Twain, that faith is belief in something known to be untrue. Now, Lt.-Col. Hunter wishes to know upon what grounds one of my fellow-correspondents wrote in the name of "your readers," and says that "it seems curious that Mr. Brady should not appreciate the objections which would accrue, *in a purely scientific* journal, by intervening. . . . in theological explanations or definitions." It seems to me equally curious that Lt.-Col. Hunter does not see that Mr. Dean was expounding theological ideas of his own *in a purely scientific journal*. He gave a definition of something which is clearly outside the domain of physical science. Lt.-Col. Hunter says further: "on what grounds does Mr. Brady write in the name of 'your readers'?" Let me ask on what grounds did Mr. Dean acquire his right to define my faith as he has done? A single thought will show that, if my faith is what Mr. Dean says it is (and he was speaking of faith in general, for he used no modifiers), and I strive to live according to my faith, I am simply acting a lie, which is just as bad as speaking a lie. In other words, Mr. Dean called me a liar. Now where is there any bigotry in my resentment of this proceeding?

I should like to ask Mr. Lighton how his assertions show that a certain quotation in his letter proves that some "exploded theories of creation" were dogmas of the Roman Church. I beg to deny that a definition of some scientific question by ecclesiastics constitutes dogma. Dr. James J. Walsh, of New York, in his book "The Popes and Science," says: "This was a deplorable mistake made by persons in ecclesiastical authority, who endeavoured to make a Church tribunal the judge of scientific truth, a function altogether alien to its character. . . . The fact that this was practically the only time that this was done serves to show that it was an unfortunate incident, but not a policy. The mistake has been to conclude that this was a typical case. . . . It was rather because of the way in which Galileo urged his truths than because of the truths themselves, that he was condemned. Even Professor Huxley, in a letter to Professor St. George Mivart, November 12th, 1885, said:—'I gave some attention to the case of Galileo when I was in Italy, and I arrived at the conclusion that the Pope and the College of Cardinals had rather the best of it'."

Yours sincerely,
CHARLES C. CONROY, A.M.

SAINT VINCENT'S COLLEGE,
LOS ANGELES, CALIFORNIA.

POLLINATION OF THE SPOTTED ORCHIS.

To the Editors of "KNOWLEDGE."

SIRS,—It may be of interest to record that my neighbour, Mr. W. Marriott, on June 11th, took a longicorn beetle, *Grammoptera tabacicolor*, with two pollen masses of this Orchis attached to its head. The beetle, which is a well-known flower-frequenting species, was taken on the Orchis, and had doubtless just acquired these appendages.

Some weeks ago I had a specimen of the Humble Bee, *Bombus lapidarius*, sent with the pollinia of *Orchis morio* attached.

I am, very faithfully yours,
(REV.) E. N. BLOOMFIELD.

GUESTLING RECTORY,
NEAR HASTINGS.
June 27th, 1910.

THE INTERMEDIATE AVENS.

To the Editors of "KNOWLEDGE."

SIRS,—It would be interesting to me personally, and I believe also to students of Botany generally, if some observations and opinions of competent workers in reference to the variety of Avens known as *Geum intermedium* could appear in your valued columns. I am venturing to send you the following observations in the hope that you can find room for them, and that they may be the means of securing notes from others who have observed analagous peculiarities.

According to theory the Avens ought to have but five petals; but last year, in the island of Arran, I found a specimen of *Geum intermedium* with ten. Mr. Daniel Ferguson, M.A., a keen Renfrewshire botanist, tells me he has found a specimen with eight. These two observations led me to think that this flower, usually considered a hybrid, exhibits

a strong tendency to variation. This opinion has been confirmed by my finding two separate specimens near the river Gryffe in Renfrewshire, on May 28th.

Of specimen No. 1, I enclose a photograph (reproduced to form Figure 1). It exhibits some remarkable peculiarities which I will describe as exactly as I can.

In the first place there is a noteworthy development of the calyx. The sepals, instead of being short as in ordinary specimens of Avens, have developed a leafy appearance and might, by the casual observer, be mistaken for a whorl of leaves. These sepals are unequal in size. Two are about one-and-a-quarter inches long, ovate, acuminate, three-lobed, serrate. Three are of same description, but about an inch long; and five, making a total of ten, are small, varied in length and form, the longest barely half an inch long, the smallest about a quarter of an inch. The sepals, of course, are united at the base; they are conspicuous for their green coloration; they are, however, tinged with red at the base and along the veins.

FIGURE 1.

An abnormal flower of Avens.
Geum intermedium.

The petals are buff, strongly tinged with red; they make a circle of about an inch in diameter. There are no less than eleven fully developed; of these two are smaller than the average. In addition, there is one small, badly grown, recurved petal, growing in the line of stamens and unmistakably developed from one of them, as it still bears traces of a yellow anther at its base (see Figure 2). What is even more remarkable is the appearance of another embryonic petal unquestionably a stamen on the way to petalhood (see Figure 3. It has grown a short, narrow, crumpled, red-tinged appendage at the end of the filament. One of its anther-lobes has disappeared, probably having been absorbed into the substance of the embryonic petal, but the other anther-lobe remains as a testimony of the evolutionary process. Specimen No. 1, therefore, has eleven petals and the promise of two more.

FIGURE 2.
A petaloid stamen.

FIGURE 3.
A petaloid stamen.

In this specimen the development of the two new petals from stamens has led to a thickening of substance at their base, which has pushed the pistil to one side of the flower.

Specimen No 2 has the same development of calyx as No. 1. As to its petals, it has eleven fully developed; two well-developed, but bearing distinct evidence of having been evolved from stamens, as they still bear traces of anthers; and two embryonic petals actually growing from between the two anther-lobes of two of the stamens.

Years ago, *Geum intermedium* was considered of rare occurrence in the Clydesdale; now it is frequent. It would seem as if it is a variation of *Geum* that is calculated to succeed. From observations made, it is certainly very variable; may it not be a variety which, after further developments, will settle down into a species? It seems to be by no means settled in its form as yet. It tends to develop numerous petals from its stamens, as some of its cousins in the Rose order have been made to do by cultivation. Whether an increase of petals would be an advantage to *Geum* has yet to be determined.

I should welcome any notes and opinions that any of your readers are disposed to offer on this interesting topic.

Very truly yours,

(REV.) CHARLES A. HALL.

MEERSBROOK,
MEIKLERIGGS,
PAISLEY.

TAILOR ANTS.

To the Editors of "KNOWLEDGE."

SIRS,—I was rather amused to read, in the June issue of "KNOWLEDGE," the paragraph on "Tailor Ants" (*Oecophylla smaragdina*), beginning "One must confess to a feeling of relief."

I have many times watched these little people making their nests and can confirm everything contained in the note in question. The formation of the chains is quite interesting to watch. No. 1 ant fastens on to the edge of the leaf with its mandibles, and then proceeds to work itself backwards by means of its three pairs of legs until it is strained to the utmost. There may be a dozen ants in the same position, shoulder to shoulder. Now come the late arrivals, and, we will say, finding no room alongside, take hold of the "waist" of No. 1 ant (or ants) straining themselves backwards in the same way. When they are firmly fixed No. 1 ant leaves go with its feet and No. 2 does some more pulling. The same thing occurs with Nos. 3 and 4; thus they gradually get the edge of the leaf turned up, and, of course, the more it bends over the easier it is to pull. When they get to the opposite edge the last ant holds on until the one in front of him has got a hold, who, in turn, holds on until the one to the waist of which he is fastened has got his feet fixed, and so on. The last ant, i.e., the one who first started pulling, remains, holding the edges together, until the ants with the larvae have done their work and made the joints secure with silk.

Sometimes one will see an ant, with a larva in its mandibles, stalking aimlessly about on the outside of the nest. It stumbles on a small hole. It proceeds to study that hole, walks all round it, walks over it (like the late Mark Twain's famous "Blue Jay" yarn), and eventually decides that it really *is* a hole, whereupon it proceeds to business. Feeling round the edge with its antennae it dumps the head of the larva on one side so as to fasten the thread of silk there, moves over and fastens it down on the other side, comes back again, and so on; each trip leaving a thread of silk behind, until the hole is completely sealed up.

If you care to have practical proof of the above I can send you specimens of the silk "paper," leaves, and insects with larvae in their mandibles. I have one of the latter in my cabinet now, but, being pinned, it would not travel in an envelope.

Yours faithfully,

L. G. GILPIN-BROWN.

CLOVIS ESTATE,
KURUNEGALA, CEYLON.
July 8th, 1910.

[NOTE.—A letter has been received from "Enquirer," but as he does not conform with the rules and give his name and address it is held over.—EDS.]

A SCIENTIFIC CLASSIC.

By REV. E. W. BOWELL, M.A.

"You say your letter on internal anatomy occupies fifty pages. Don't you think you can reduce it to smaller compass? "for it strikes me that, considering the variety of matter we have to handle, that, unless we attend to brevity, we shall have "our work extend to two or three volumes."—(KIRBY to SPENCE, August 15th, 1810.)

JUST a hundred years ago the Rev. William Kirby, F.R.S., Rector of Barham, was busily engaged with his friend William Spence, Esq., F.R.S., of Drypool, in planning their justly celebrated *Introduction to Entomology*. Mr. Kirby had been for many years a diligent collector of insects, especially of bees and beetles; Mr. Spence's first love had been political economy, but he became an entomologist in 1805. Their joint work was published in 1815, and seems to have met with immediate appreciation. It is much too good a book to be forgotten, though the science of entomology has undergone many changes since the year of Waterloo. It is scientific, for it contains a large array of facts and criticisms, marshalled in a new and ingenious manner, for the purpose of exciting interest and stimulating further enquiry, and thus handing on the torch of scientific knowledge. It is a classic, because it is a record of sound and genuine thought expressed in good literary form, and the authors have nowhere tried to conceal the fact that they were interested in many other matters besides entomology; indeed, they infect the reader with enthusiasm for their subject by showing in how many ways it is connected with human affairs. And so, although they have occasion to discourse of amphiarthroses and parapleura, of Chartergus and Myrapetra, their writing never becomes dry and impersonal. They introduce us to the great men of the past; we have the honour of conversing familiarly with Madame Merian, with Dr. Martin Lister, with Reaumur and Swammerdam and Huber, and many more. It is well to meet with these courtly personages; it is well to be reminded that Aristomachus devoted fifty years to the study of bees, and that much thoroughly good and thoughtful scientific work was done before the great renaissance of the nineteenth century.

The *Introduction* was not issued without definite purpose. The authors had become convinced independently that there was an actual need of such a book as they could write, and they calculated to supply that need. In comparison with the other noble occupations of mankind, Entomology was then (as it still is) very lightly esteemed; but it was even frowned at, as being inhuman and contemptible. So, besides being an Introduction to Entomology, this book was also the *Apologia* of Messrs. Kirby and Spence; it served to demonstrate to the educated reader that their proceedings, though unusual, were not irrational. Thousands of gentlemen would flock to see a prize fight, or to hang about at a levée, and therefore such occupations were reasonable and sane. But to spend hours in the attempt to capture some inconspicuous insect, or in watching the ways of bees and ants and various grubs, seemed perilously near to insanity. It was necessary to show that it might be justified. In our own days it is probable that the mechanic who spends his spare time with microscope or telescope, or in collecting specimens, will be considered a little "dotty" by his comrades who betake themselves to entertainments more usual and less intellectual; and one may hazard the conjecture that it is largely due to Messrs. Kirby and Spence that such an estimate of the amateur naturalist—the man who is a naturalist because he loves natural history—is not more general even now.

They were missionaries, and their object was to effect conversions. Hence, in the quotation given, above, we find Kirby gently insinuating to his colleague that a little economy must be exercised with regard to the more recondite parts of the subject. It may be that he intuitively suspected that the science of internal anatomy was in a somewhat embryonic condition. Great entomologists, like Westwood, have with reason shared this view down to recent times. But on turning over the pages of the *Introduction* we see at once that a vast deal of entomological work was done before the formulation of orthodox opinions about internal anatomy. The chitinous parts had been studied in great detail, and some attention had been paid to the homologies of these structures, as if naturalists recognised that there was some interesting relation between similar parts long before they were ready to formulate a doctrine of descent. It was upon such matters that Charles Darwin's mind was exercised a few years later, to the displeasure of those who were trying to instruct him in (other) ways of wisdom. It may be that that rather indefinite course of beetle hunting had more to do with the intellectual training of our greatest naturalist than has yet been suspected. At least it must have given him preliminary views of the largeness and complexity of natural phenomena which he could not have gained from the study of selected types.

But the most interesting and valuable parts of our "scientific classic" are those which are occupied with the description of insect economies. It is easy to misuse the imagination in such matters, and our authors show that they had the gift of shrewd criticism; perhaps few naturalists have possessed it to the same extent. He that would learn it should look into their pages. While critical, they are always courteous; which is not always easy. In so large a

collection of facts there must necessarily be some to which we should feel bound to affix a question-mark; but the number of such statements is remarkably small. This may be in part due to the intense criticism which we know they bestowed on their own work. Every one of the sections here is suggestive, and might still be provocative of useful research, so that to any entomologist who is tired of mere collecting (no bad thing in its way), one may recommend a reference to their well-reasoned Table of Contents. He will certainly find some line along which observations may advantageously be made, especially if he can avail himself of modern optical instruments. But even without anything of the kind, with no apparatus beyond notebook and pencil and simple magnifier, good observational work may still be done; and though methods improve every day, Kirby and Spence's work teaches well what to observe.

It is not necessary that we should take much notice of the few outbursts of entomological poetry which occur in the *Introduction*, except to remark that many of the early entomologists were very chirpy songsters, though Erato now favours us no longer. The Rector of Barham's theology, which is closely connected, as it should be, with his entomology, will seem to some readers to need revision; but there is no denying that it is good solid orthodox stuff, and, above all, evidently honest and genuine. Perhaps the most attractive part of the whole book is the excellently written letter on Instinct. We do not need to agree with all the writers' conclusions, but we cannot fail to admire the way in which they set forth the surprising nature of the observed facts. The interpretation of those facts is still an open question; to the field naturalist they will always appeal with greater force than to others; our authors were field naturalists—they often stood face to face with this marvellous thing. This is perhaps the reason why their treatment of the whole subject is so eminently thoughtful; it is a reason for recommending the study of entomology to thoughtful persons.

A SMALL IMPLEMENT OF CRYSTALLINE QUARTZ FROM PEMBROKESHIRE.

By A. L. LEACH.

IN KNOWLEDGE for May, 1910, Mr. A. S. Kennard, F.G.S., in describing certain implements of quartz from Africa, referred to the rarity of those made from this mineral, and mentioned two localities, as recorded by Mr. Clement Reid, where they have been found in Britain. These are Banffshire, where small neolithic flakes of white quartz were found, and Prah Sands, where the flakes were of vein quartz and of pleistocene age.

A few years ago I obtained from a "chipping floor" amongst the sand dunes at Freshwater West, in South Pembrokeshire, a tiny implement chipped out of pure translucent crystalline quartz (see Figure 1). It is almost triangular in outline, nine-sixteenths of an inch long and of nearly equal measurement at the basal end, where it is four-sixteenths of an inch thick. (Its size is shewn in the diagram, Figure 2). The thickness is greatest just above the base and thence diminishes towards the blunt point. The lower surface of the implement shows a smooth, slightly concave surface with a little secondary working near the edges, but the upper surface has been shaped by the removal of many very tiny chips. An opaque white patch (shewn in the photograph reproduced to form Figure 1) appears to be a remnant of the weathered crust of the original crystal. The little tool is so small, its weight being but 1·6 gramme (twenty-five and-a-half grains) that it may well be termed a "pygmy" implement. I am glad to be able to state that Mr. Kennard, who has examined the specimen, agrees with my view that it is undoubtedly a worked implement.

From a photograph by G. Y. B. Lockwood.

FIGURE 1.
A Small Implement of Crystalline Quartz.
Freshwater West, Pembrokeshire.

FIGURE 2.
Diagram showing the exact size of the Quartz Implement.

The age of this pygmy quartz is probably neolithic. From the site I have obtained several small neatly-worked scrapers of flint, and also a well-worked arrowhead closely resembling in size and shape an arrowhead from the Yorkshire Wolds, figured in Evans' *Ancient Stone Implements*, 2nd Ed., Fig. 293. These flint implements have a white porcellanous surface, and are slightly polished by sand friction. The surface of the little quartz implement is similarly glazed or dulled, and its edges, we may say, are gently rounded, probably by the long continued action of the drifting sands which were found to surround the chipping-floor.

A NEW PROCESS FOR PRODUCING METALLIC COATINGS.

By F. MOLLWO PERKIN, PH.D., F.C.S.

THE ancient Egyptians knew the art of coating certain metals with copper, as is instanced by iron articles coated in this way which have been discovered with their mummies. The method, in all probability, was to dip the iron article in a solution of copper sulphate, which might very likely be obtained from the atmospheric oxidation of moist copper pyrites.

Very shortly after the discovery of Volta's Pile, in 1800, the possibility of depositing metals from their salts upon other metals, by means of the galvanic current, was noticed, and gradually became an art. As electrical knowledge advanced and batteries were improved, so the process ripened into an industry, until, with the introduction of the dynamo, it has become a most important everyday business. Metals are now coated with nickel, copper, zinc and the rarer metals in order to protect them from atmospheric corrosion, and also for artistic effect.

Another method for protecting metals, chiefly iron, from the effect of the atmosphere is galvanizing. That is the dipping of the iron, either in the form of sheets or made-up articles, in molten zinc. Then of course there is the beautiful protective covering given by dipping into molten tin, so that one talks of tin boxes and so on, when tinned iron boxes is meant.

There are, however, objections to hot galvanising, owing to the metals partly alloying with the hot metal constituting the bath, which thus gradually becomes contaminated and requires renewing. There is also the large amount of fuel required and the tendency of certain made-up articles to distortion when dipped hot, and there is also the spoiling of tempering of goods which have been previously tempered.

A few years ago a process by means of which metals can be coated with zinc at a temperature of about 200° C. was discovered by Mr. Cowper Coles. He had covered some iron articles with zinc dust in connection with some experiments on tempering, and after heating for some time to about 200° the articles were withdrawn, when to his surprise they were found to have obtained a beautifully adherent deposit of zinc. Now since zinc melts at 418°C. this process obviously possessed great advantages over the dipping process. Another advantage is that the deposit is beautifully smooth, and even small screws may be treated in this way without it being necessary to re-thread them.

This process, called sherardising, has another advantage: an article can be coated in parts only if desired, so that designs can be traced out, say on copper or brass with zinc, and after polishing a very beautiful effect can be produced. The method of procedure in this case is to cover the parts which are not to be coated by means of a stopping mixture. The whole article is then placed in an iron box, covered with zinc dust and the box heated to the desired temperature. On taking it out at the end of a certain time, depending upon the thickness of the coating desired, it is found that the zinc has only adhered in the uncovered parts.

A new process of very considerable interest has just been invented by Mr. U. Schoop, of Zurich. The chief point in it is that the metal in a liquid condition is sprayed upon the surface to be coated, in the form of a very fine mist. The atomising of the metal may be brought about in a variety of ways. The metal is melted in a closed crucible and is forced out of a nozzle by the pressure of gases or vapours. Or the subdivision of the metal may be brought about by causing two jets of metal to pass out of separate nozzles, so that they meet at a suitable angle. When the two jets, which of course are forced out under pressure, meet, they, so to say, tear each other apart and a very fine spray of liquid metal is produced.

The most satisfactory method, however, appears to be to cause the subdivision of the metal by the use of compressed gases of a kind which exert no oxidising effect on the metal. The metal which is to be employed for coating purposes is melted in a closed crucible which has a pipe at the bottom, ending in a nozzle with a capillary opening. Another pipe enters the upper part of the crucible and is connected with a source of compressed gas, the gas being previously heated by passing through a coil heated by means of gas burners. Another tube is connected externally with the gas pressure tube and ends in a nozzle which is situated below the metal outlet. The compressed gas impinges with great force on the fine stream of metal which is also being forced out under the same pressure. The metal is thus very finely atomised and is blown against the article to be coated. Various gases may be chosen to press the metal out of the nozzle, for example, an inert gas such as nitrogen, and this may also be used for atomising. But, on the other hand an oxidising gas may be taken. It has, for instance, been found possible to produce coatings of lead peroxide of a firmly adhering character, by using air or oxygen.

Different metals naturally behave differently, according to their fluidity, melting point, oxidisability and so on. The material of the crucible moreover depends upon the metal which is to be melted

in it. Thus, for aluminium and its alloys iron or steel crucibles cannot be used. It appears, indeed, that under pressure, metals alloy much more readily and quickly than under ordinary atmospheric conditions. Obviously alloys may be melted and sprayed, but the metals require to be mixed in their eutectic proportions.

What probably happens in the spray process is that when the metal is forced out under pressure, and leaves the nozzle, it is met by the gas stream, also under pressure. The stream of metal is thus torn up and converted into a mist. The individual particles of the metal when sprayed on to the surface to be coated lose their surface tension and their globular form and are pressed out on the surface as a circular film. The circular films overlapping, become automatically welded into a continuous homogeneous coating. Calculation shows that with a pressure of twenty-five atmospheres, the metallic particles have a speed of twenty kilometres per second, *i.e.*, twenty-five times the speed of the bullet from the gun used in the German army. Owing to this enormous speed of the metal mist, metallic surfaces of a surprisingly high density are produced. For example, the density of rolled tin was found to be 7·47, and that of the sprayed tin 7·42.

A point of great interest is that the metallic mist is at a comparatively low temperature, at about 40° to 60° C, in spite of the fact that the molten metal as it is ejected has a temperature of several hundred degrees, and so also has the atomising gas. This rather surprising fact Mr. Schoop considers to be due to the sudden reduction of tension of the gas whereby the metal mist, which presents an enormous surface, is also cooled. This cooling, however, is a very great advantage, because it is possible to give a metal coating to substances of low melting point or of high inflammability, such as paper, wood, celluloid, wax, and the hardness of the metal film is greater than the hardness of metallic films produced by other methods, e.g., casting or rolling. This great hardness should be of advantage in the manufacture of electrotypes and cuts, in which hardness is an important feature. Microscopic examination shews that the surface is also absolutely homogeneous.

In carrying out the operation, the metallic surface to be coated is first freed from oxide or adhering dirt. In many cases, especially when metals are to be coated, it is found advantageous to heat the surface previous to spraying on the metal. It is not, however, absolutely necessary to do this, consequently, with a portable apparatus, metallic structures such as bridges, machinery and so on, could easily be coated, and it is claimed that it would be no more expensive than painting. As to the applications of the process, they are almost numberless. It may be used for all cases in which plating is at present employed, and for many articles which cannot be readily plated. Paper may be coated with metal so that it can be used for packing such things as chocolate, tea, and so on. The envelopes of balloons can be treated—an aluminium coating $\frac{1}{30}$-m.m. thick is sufficient to render them quite gas-tight.

The wooden propellers of aeroplanes coated in this manner are protected against the action of the weather, and the air friction is considerably reduced. Wall paper, stage scenery, and textiles can all be coated with metals.

Certainly the process is one of great interest, and one point of particular note is—it is now possible to coat metals with aluminium, which will be perhaps one of the most useful applications of this new process; because at present, although many pafents have been taken out for coating metals with aluminium, they are none of them of any use. If iron or steel articles could be covered with aluminium, *i.e.*, plated, they would be made to withstand atmospheric attack better than by any process of which we at present know.

THE MANCHESTER MICROSCOPICAL SOCIETY.

EXTENSION SECTION.

THE objects of the Extension Section of the Manchester Microscopical Society are to spread the knowledge of microscopy and natural history to outside associations by means of lectures and demonstrations, and the thirteenth list of lecturers lies before us. It contains no less than sixty-one subjects on which members of the Manchester Microscopical Society are prepared to speak. In all cases the work on the part of the lecturers is voluntary and gratuitous, though on occasion a small fee is asked for in addition to out of pocket expenses, and this is always done where the lectures are given before societies which are commercial undertakings or subsidised out of Government or public grants. Some of the lectures can only be given in particular neighbourhoods, but all details of the work can be obtained from Mr. R. Howarth, the Honorary Secretary, at 90, George Street, Wheatham Hill, Manchester.

It should be pointed out that the whole intention is to bring scientific knowledge before societies that are unable to pay large fees to professional lecturers. The topics chosen for lectures, range from ponds and rock pools to marriage customs in the plant world, and from insect anatomy to prehistoric man. In fact there is such a wealth of material that there should be no difficulty on the part of any society in finding something of interest to its members.

The Manchester Microscopical Society is greatly to be congratulated on its successful endeavours, and on the public spirit of its members.

XUM

JOHANN GOTTFRIED GALLE.

By F. A. BELLAMY, M.A., F.R.A.S.

RECENT years have dealt severely with our veteran astronomers, and we have at last to deplore the death of that aged worker in practical astronomy, Johann Gottfried Galle. While he lived, we might truly say that we had the connecting link with some eminent astronomers of the middle of the eighteenth century, for W. Herschel lived until 1822, and Laplace and Piazzi were old but still active workers when Galle was born at Pabsthaus, near Wittenberg, on June 9th, 1812. He was at first employed as a first-class teacher, or master, at the gymnasium of Guben and at the Friedrichs-Werder's gymnasium at Pabsthaus. In 1832, on October 22nd, the foundation stone for the new observatory at Berlin was laid, and the building was proceeded with under Prof. J. F. Encke's direction during the years 1832-1835. On April 24th of the latter year the dwelling house was finished, and the first time-determination was made on May 19th with the small Ertel Transit. Coincident with the moving to the new building was the appointment of J. G. Galle as the assistant, at the age of twenty-three. Here he was soon amply employed in the multifarious duties which require regular, systematic, and constant attention, always to be found necessary in such observatories in which practical astronomy, meteorology, and magnetism are carried on. The early volumes issued by the Berlin Observatory testify that a very large portion of the observational work was accomplished by Galle, whether bi-daily magnetic observations, tri-daily meteorological observations and their reductions, transit and circle observations, or work with the refractor: it should be stated, however, that Encke and Mädler made the majority of the transit and circle observations in 1836-9.

The first recorded observation of a double-star by Galle is ρ Ophiuchi in 1836, July 1st, and after the end of 1837 to 1839 he observed almost all that are printed in the Berlin volumes. This is a brief summary of his observational work for the sixteen years he remained as an assistant at Berlin: all the thrice daily meteorological observations 1835-1851; for the same period he equally shared with Encke, the director, the twice daily magnetic observations; half, or more than half, of the observations of Jupiter's satellites 1836-8, of comets 1838-1846, of occultations of stars 1839-1846, of planet diameters 1836-9—Galle sharing with W. Struve, Bessel, and Encke in the priority of this particular class of observation—of the minor planet Astraea in 1846; and he made the meridian observations 1840-1846, and their reductions, besides the reductions and discussion of the meteorological and magnetic observations. Though this record is abundant evidence of his activity and utility during his period at Berlin, it is by no means all. The infrequent publication of the Berlin volumes did not provide a ready means for expeditiously disseminating papers or notes by energetic workers, such as Galle. The periodical known as the *Astronomische Nachrichten* was then, as now, published two or three times a month, and afforded Galle, either directly or through Encke, an opportunity of quickly recording his observations in print and so making them known at once to the astronomical world. The series is now in the clxxxv volume, and Galle's first paper, *neue Elemente der Pallas für 1810*, is in vol. xiv. (1836); from then until 1843 twenty-four communications were made by him. And, until near his retirement at the age of 85, he was a frequent contributor to those pages, though naturally less active in the later period. The subjects upon which he wrote were various; besides astronomical subjects, he was keenly interested in the discussion upon the movement of storms, and in optical or non-instrumental meteorology. In astronomy his sympathies were sufficiently comprehensive to incite him to write more or less briefly upon such varied topics as the observation and discussion of Minor Planets and their elements; Total Eclipses of the Sun and Moon; Longitude; Meteors and their cometary associations; Comets, their observation, ephemerides and orbits; Solar surface; Diameters of Planets and Transit of Mercury; Saturn's Inner Ring; Solar Parallax from Minor Planets; and Neptune. Reference has already been made to his meridian, magnetic and meteorological routine labours at Berlin.

Galle proceeded to his doctor's degree in 1845, and offered as his dissertation, "*Olai Roemeri triduum observationum astronomicarum a MDCCVI—institutarum reductum et cum tabulis comparatum*": 50 pp. + vita, 4to., Berlin, 1845. These observations were made by Römer at his observatory near Copenhagen, on October 20th to 23rd, 1706, and are all that survived the destructive fire at Copenhagen in 1728, when seventy-seven streets were destroyed.

Other researches by Galle were "*Bestimmungsstücke der Bahn aller bisher berechneten Cometen*"; this forms Table VI, pp. 155-233, in Encke's edition (the second) of Olber's "*Abhandlung uber die Bahn eines Cometen*," published at Weimar in 1847. This table contains the elements of 178 comets, by various calculators, from B.C. 371—A.D. 1847, together with historical information; much time must have been spent by Galle in collecting such valuable information. Galle wrote the preface and edited a third edition in 1864 (Leipzig); it was a reprint of the former edition and a "Fortsetzung und Ergänzung" was included, forming pp. 254-334, and a continuation of the catalogue to the end of 1863, bringing the number to 282. He must have been keenly interested in this subject, for in 1885 he sent a further supplement to the *Astronomische Nachrichten*, CXII, Nos. 2665-6, and in 1894, nearly fifty years after the publication of his first catalogue, and at the age of 82 he prepared and published, with the aid of his son, Dr. Andreas Galle, of the R.

XUM

Geodetic Institution in Potsdam, a new work entitled "*Verzeichniss der Elemente der bisher berechneten Cometenbahnen nebst Anmerkungen und Literatur-Nachweisen . . . zum Jahre, 1894*," 316 pp. + XX, 8vo., Leipzig, 1894. It differs from the earlier work in the omission of all Olber's explanatory details, calculations and tables; but corrects and amplifies the original Table VI of 1847, and brings the number of comets to 414. Before passing from Galle's cometary work, it is a pleasure to state that when 27½ years old he succeeded in discovering three new comets in three months—1839, December 2nd; 1840, January 25th; 1840, March 6th. This must be a record for speediness in this work: it is strange that he did not give attention to it in later years.

Another important and useful piece of work accomplished before he left Berlin was the "*Register zu von Zach's Monatlicher Correspondenz*," . . . . 220 pp.+ x., 8vo., Gotha, 1850. Galle's position as Assistant at the Berlin Observatory ceased on his appointment as Professor of Astronomy in the Royal University, and Director of the Observatory at Breslau; his last observations at Berlin were made fifty-nine years ago, in 1851, October 26th.

The Observatory at Breslau was built in 1790; its first Director was Dr. Jungvitz, the second was Dr. O. Boguslawski; he was succeeded by Dr. J. G. Galle in 1851, and the dual position was held by him for forty-six years, until his retirement in 1897; so the Observatory was controlled by these three for more than a century. Besides his university duties of instruction he continued his observational work, though on the whole with less vigour than when at Berlin, and published his observations, notes, and discussions as hitherto, in the *Astronomische Nachrichten*. From 1851 to 1897 his work gravitated and was mainly restricted to the cometary and planetary part of Astronomy; and three separate papers or pamphlets on those subjects were published at Breslau in 1858 (18 pp.), 1865 (43 pp.), and 1875 (72 pp.), the last being a novel and epoch-making paper—*The Determination of the Solar Parallax by the Utilization of Minor Planets*. It has already been pointed out that during his Breslau period he published two more editions and a supplement to his important catalogue of comets and their orbits; one being a new and independent book, more than double the amount of comets being accounted for than in his original Table VI in Olber's (Encke) treatise of 1847. This volume of 1894 is unsurpassed in its completeness and in the great amount of historical details and valuable information contained in very concise compass. It is an important contribution of permanent value to Astronomy, and a class of spade-work, one may call it, that receives little acknowledgement or expressed appreciation during an author's lifetime, as we think in this particular instance. The time between 1844 and 1894 that Galle gave to these catalogues of comets must have been immense; we know a day may often be spent hunting for such records without acquiring a single additional reference.

So far back as 1838 Galle made an important discovery of Saturn's inner dark ring—we might say independent re-discovery, for there exists some evidence of it in drawings by Picard in 1673 and Hadley in 1720, possibly by others before and after these two observers, for the drawings are somewhat crude, and there is an uncertainty as to what they really saw or intended to depict. Galle, then an assistant of twenty-six at Berlin, observed with the nine-and-a-half inch equatorial that in the space between the globe and the inner edge of the inner bright ring of Saturn there was another ring; he noticed a gradual diminution or shading from the ring towards the globe—since called a veil, or the crêpe ring—and at once sent in a note of the observation, which was printed in *Mathematische Abhandlungen Königl. Akademie Wissenschaften, Berlin*, 1838, p. 7. There it seems to have remained unread and unknown until the dusky ring was re-discovered by W. Bond at Harvard College, U.S.A., and W. R. Dawes, in England, in November and December, 1850, which announcement brought forth a note from Galle (*Ast. Nach.* XXXII, No. 756, 1851) drawing attention to his previous observation: reference was also made to this, giving Galle the credit, in *Monthly Notices of the R.A.S.*, XI., p. 184.

Another important paper by Galle was that in the *Ast. Nach.*, No. 1897, for the year 1872, in which he suggested a method of determining the sun's distance or solar parallax by utilising the minor planets at opposition. The proposal was to measure with an equatorial the relative distance of a planet from stars selected slightly to the north and south of its course. A favourable opportunity occurred in 1873, when the planet Flora was at opposition in November and December. Galle invited the coöperation of observers at observatories scattered in both hemispheres; he had in 1872 used the planet Phocaea, but unsuccessfully. The results were discussed by Galle, and published in 1875 at Breslau in a paper, *Ueber eine Bestimmung der Sonnen Parallaxe aus correspondiren den Beobachtungen des Planeten Flora in October und November, 1873*, and a value of $8''.82 \pm 0''.06$ was deduced for the solar parallax: a result much nearer the value at present accepted than those deduced from the major planets, Venus and Mars. The proposed method was of the highest importance, and has become the universally accepted plan for the determination of the most accurate value of the solar parallax. In later years Galle's method was adopted by Sir D. Gill and others with excellent results, the planets, Victoria, Sappho, and others, having been utilised: that the value obtained by Galle was not more accurate was due to the want of homogeneity of the material sent to him, to the unsystematic character of the observations, to the unsuitable instruments that were used, and not to his defective scheme.

(To be continued).

XUM

THE VARIATION OF LUMINOSITY WITH TEMPERATURE.

By G. NELSON, B.Sc., A.R.C.S.

THE comparative simplicity of photometric observations has led to the development in recent years of methods of measuring high temperatures based on the variation of the luminosity of the glowing body. It is proposed to give in the following an outline of the principles involved, and to indicate the more important historical developments of the subject.

Experiment has shewn that, so long as the illumination is not too feeble, the intensity of illumination, i.e., the quantity of light falling on unit area of an illuminated surface in unit time, varies inversely as the square of the distance of the source, supposed of small dimensions. The same law is accurately true for the intensity of the energy from the same source. It follows, therefore, that the luminosity of a source of light emitting energy lying wholly between wave-lengths λ_1 and λ_2 which are very close together, will be proportional to E_λ, the energy which the source emits per second per square cm. lying between the same limits of wave-length; light of this kind may be termed *monochromatic*. The constant of proportionality will differ with the wave length (or colour), being small in the blue region of the spectrum, of a maximum value in the yellow-green, and falling to zero in the red or longer wave length region. This variation in the constant is of course a peculiarity of the eye.

The *total* energy of radiation varies in general with the nature of the radiating body, the polish of its surface, and the value of the absolute temperature, θ, of the body. There is, however, one kind of such radiation which is independent of the nature of the matter from which it emanates, and is called "*black body*" radiation. It has also been called more recently *full* radiation. This radiation is that which would be emitted by a hot body possessing the property of absorbing completely radiation of all wave lengths. Although substances which appear deadblack to the eye, such as lampblack, approximate in their radiating properties to this ideal *black body*, the ideal has not been found in Nature. It was, however, shewn independently by Kirchhoff and by Stewart, about 1858, that the radiation inside an enclosure maintained at constant temperature—an *isothermal* enclosure—was independent of the nature of the walls of the enclosure, being identical in every respect with what would be emitted at the same temperature by the black body.

The law which governs the distribution of the energy amongst the various wave lengths, of indefinitely large number, which constitute the spectrum of full radiation, has been the subject of much discussion and experiment. Many formulae have been proposed, but the one given by Wien in 1896 was the first which had any satisfactory basis in theory. The deduction of this form of *emission function*, as the law may be termed, depends on the fact that radiation, as was shewn by Maxwell from the electromagnetic theory of light, exerts a pressure on any surface upon which it falls. This property allows the radiation to be used as the working substance in a thermodynamic cycle. Using in addition the alteration of wave length which occurs when a train of waves is incident on a moving surface, such as is used in the thermodynamic cycle, Wien was able to shew that the emission function must be of the form

$$E_\lambda = C\lambda^{-5} f(\lambda\theta)$$

where C is a constant and $f(\lambda\theta)$ is a function of the product $\lambda\theta$, the form of which has yet to be determined.

By making further assumptions, which were by no means so well justified, he obtained

$$f(\lambda\theta) = e^{-\frac{c}{\lambda\theta}}$$

where c is another constant, and e the base of the natural system of logarithms.

This expression is quite adequate to represent the ascertained experimental facts, provided that the value of the product $\lambda\theta$ is not unduly large. Owing to discrepancies outside this limit, Planck on somewhat different assumptions put forward the expression

$$f(\lambda\theta) = \frac{e^{\frac{c}{\lambda\theta}}}{e^{\frac{c}{\lambda\theta}} - 1}$$

This formula has been found much better than Wien's, to which it approximates when $\lambda\theta$ is small, having been verified for values of $\lambda\theta$ from 500 to 100,000 (1μ = ·00001 cm. is the unit of length taken here for the measurement of λ). Black body radiation is produced experimentally for such verifications, by making a small aperture in the wall of an enclosure kept at constant temperature. For the visible spectrum, with which this article is more particularly concerned, Wien's law is sufficiently accurate, as the range of wavelength may be considered as ·36—·76μ. At the temperature of the carbon arc, about 4000° absolute, a difference from Planck's formula of about 1 per cent. would be found for $\lambda = \cdot 7\mu$.

The full expression of Wien's Law is

$$E_\lambda = C\,\lambda^{-5} e^{-\frac{c}{\lambda\theta}},$$

expressed logarithmically to base e,

$$\log E_\lambda = \log C - 5 \log \lambda - \frac{c}{\lambda\theta}$$

which, if $a = \log C - 5 \log \lambda$

and $b = -\frac{c}{\lambda}$

becomes $\theta \log E_\lambda = a\theta + b$.

The values of a and b depend of course on the wavelength taken. Since the luminosity ϕ_λ corresponding to E_λ is proportional to the latter quantity,

$$\theta \log \phi_\lambda = A\theta + B$$

The temperature of a black body can be obtained from an observation of the luminosity ϕ_λ by putting the equation on the form

$$\theta = \frac{B}{\log \phi_\lambda - A}$$

Thus between $\theta \log \phi_\lambda$ and θ there exists a linear relation. The straight line obtained by plotting these quantities is called an *isochromatic*; the method has been used with monochromatic light to test Wien's law in the visible spectrum.

Le Chatelier and Boudouard gave the earliest results on the relation of monochromatic luminosity and temperature. Although published before Wien's Law, the numbers are represented by it at least as well as by the formula they originally proposed, $\phi_\lambda = A\theta^{-\frac{a}{\theta}}$. All subsequent observers have confirmed the law of Wien.

INTEGRAL OR TOTAL LUMINOSITY.

It has been suggested by Blondel, Crova, and others, that the total luminosity of a glowing body is proportional to the luminosity of a particular wavelength in the neighbourhood of the yellow-green of the spectrum. This assumption, which is approximately true, may be applied as follows.

The total luminosity ϕ, being supposed proportional to ϕ_λ at a given wavelength, must therefore be of the form

$$\phi = A\, e^{-\frac{a}{\theta}} \text{ or, } \theta \log \phi = A\theta + B.$$

B, A, and a being constants.

Thus an equation of the same form as the isochromatics is obtained. For black body radiation, numbers by Lummer and Pringsheim are approximately fitted by an equation of this type.

Experiments have been made on the rate of change of total luminosity with temperature, in the case of polished platinum. This substance of course cannot be a full radiator, as it reflects highly in the visible spectrum. The experiments have, however, evoked considerable discussion.

Petavel in 1898 gave an expression which may be written

$$\phi = \left(\frac{\theta - A}{B}\right)^n$$

A, B and n are three arbitrary constants.

Lummer and Kurlbaum (1900) obtained results which may be stated thus. If $d\phi$ be the increment in luminosity corresponding to an increment $d\theta$ in the temperature of the platinum surface, then

$$\frac{d\phi}{\phi} = \chi \frac{d\theta}{\theta}$$

In this expression χ is a function of the temperature θ and has the following values.

θ	900	1000	1100	1200	1400	1600	1900
χ	30	25	21	19	18	15	14

These values were taken by Lummer and Kurlbaum to indicate that χ approaches 12 as a limit when θ increases indefinitely; other physicists have interpreted them differently.

Guillaume (1901) took the limit for χ as 10, and assuming that a rectangular hyperbola fitted the points obtained by plotting χ against θ, deduced

$$\phi = A\theta^3 (\theta - 650)^7.$$

Rasch had contended previously that the limit for χ should be zero. Arguing that the physiological effect of energy on the eye is electrochemical in nature he applied an equation fundamental to such processes $\frac{d\phi}{\phi} = \xi \frac{d\theta}{\theta^2}$ (ξ being a constant).

Comparing this with $\frac{d\phi}{\phi} = \chi \frac{d\theta}{\theta}$ it follows that

$$\chi = \xi / \theta$$

so that when θ is great χ gets small and tends to zero as a limit. This equation is equivalent to

$\phi = A\, e^{-\frac{a}{\theta}}$ a form deduced already under certain assumptions at the beginning of this section.

Rasch's curve agrees with Lummer and Kurlbaum's numbers within the limits of possible error. Calculations on the luminosity of a *black body* made by the present writer seem to indicate that such a law does not hold accurately even from 1000 to 2000° absolute.

It will be noticed that both Petavel's and Guillaume's formulae express the physical fact that light is not perceived until the body reaches a certain temperature. These formulae are purely empirical, and are not to be expected to give an accurate value of this temperature for the substance to which they refer, especially as for temperatures lower than this, they both give absurd values for the luminosity.

It may be remarked here that the law of Draper, which states that all bodies commence to give an appreciable sensation of light at the same temperature, has been adversely criticised by Lummer. It is doubtful whether the law applies even to the "grey glow" which precedes the real sensation of light; the latter certainly occurs at different temperatures for different bodies.

The law of variation of total luminosity of a black body cannot yet be regarded as established. In this case the variable sensitiveness of the eye in different observers causes some difficulty, and the methods which use monochromatic light have so far been the only practical ones adopted. There is in the case of both monochromatic and total luminosity, the difficulty that, unless the radiation comes from an isothermal enclosure, the temperature determined in this way depends on the radiating properties of the body.

XUM

NOTES.

ASTRONOMY.

By G. F. CHAMBERS, F.R.A.S.

GREENWICH OBSERVATORY REPORT.—The Report presented by the Astronomer Royal to the Visitors of the Observatory, contains several paragraphs of particular interest which we here reproduce:—

"In last year's Report Mr. Cowell and Mr. Crommelin's predicted dates of perihelion passage of Halley's Comet were given, namely, 1910 April 13th, by Pontécoulant's method, and April 16th by the new method of mechanical quadratures of rectangular co-ordinates, originally devised by Mr. Cowell for dealing with the Eighth Satellite of Jupiter, and subsequently adopted as suitable for this comet. The actual date is now known from preliminary discussions of the observations to be very close to April 19·68 G.M.T., which differs by 3·07 days from the calculated date, April 16·61. The hope expressed last year that neither computation was seriously in error has thus been realised, and the new method gives a result decidedly nearer to the truth than that first employed. The other elements of the orbit are also near their predicted value, the greatest discordance being 1′. Since the discovery of the comet a new investigation has been made for the period 1828-42, which includes the largest part of the Jupiter perturbations, using time-intervals half those previously employed; this investigation brought to light a few small numerical errors, whose combined effect on the period is under one day. As differencing gives a sufficient check against appreciable errors for the remainder of the two revolutions, it does not appear that more than one day of the 3·07 days' discordance between theory and observation can be accounted for by numerical errors. The remaining two days' discordance appears to be due to causes other than the attraction of known matter in the solar system."

"The rainfall for the year ending 1910 April 30th was 27·72 inches, being 3·60 inches greater than the average of the sixty-five years 1841-1905. The number of rainy days (0·005 inch or over) was one hundred and ninety-two, the highest number for many years. The greatest daily amount was on April 16th, when the total exceeded an inch and a half, most of which fell between 5^h and 9^h p.m., and more than half between 5^h and 6^h p.m. More than an inch of rain fell on June 24th. February for the first time on record provided a 'rain-spell' (more than fourteen consecutive rainy days), inasmuch as every day from February 10th to 26th inclusive was rainy."

"The automatic signals from the Westminster clock have been received regularly since the last report. On eleven days the signal failed, and on two days it was interrupted by telegraph signals. Its apparent error was not greater than $0^s{\cdot}5$ on forty-one per cent. of the days of observation, not greater than $1^s{\cdot}0$ on seventy-seven per cent., not greater than $2^s{\cdot}0$ on ninety-eight per cent., and was between 2^s and 3^s on six occasions, but never exceeded 3^s."

BOTANY.

By PROFESSOR F. CAVERS, D.Sc., F.L.S.

HYBRID ORANGES.—Some interesting observations on the hybridisation of various Oranges, and on the origin of the Sweet Orange, have recently been made by Trabut (*Comptes rendus, vol. 149*). In 1902 he obtained a new Mandarin Orange by crossing the ordinary Mandarin and a Bitter Orange, and this hybrid, which has been cultivated for eight years, has given a large number of varieties, the majority of which are Sweet Oranges, about 10 per cent. only being Mandarins and Bitters (Bigarade variety). Trabut concludes from his experiments that the Bigarade or Bitter (Seville) Orange can readily be crossed with the Mandarin, but not with the Sweet Orange; that its crosses with the Mandarin are fertile; and that the Sweet Orange, which is generally regarded as an independent species, is furnished by crossing a Mandarin (*Citrus nobilis*), and a Bigarade (*Citrus Bigaradia*), the green colour of the embryo characteristic of *C. nobilis* being persistent to this day in the hybrids with bitter fruits.

ENGLER'S CLASSIFICATION.—In the latest edition of his *Syllabus der Pflanzenfamilien*, Engler proposes some remarkable changes in the classification of the Dicotyledons, rendered necessary by recent work done since the publication of the great German encyclopaedia—*Engler an Prantl's Natürliche Pflanzenfamilien*. It is now proposed to insert a new cohort, the Garryales, between the Salicales and the Myricales, for the reception of the genus *Garrya*, which was formerly placed in the Cornaceae at the opposite (highest) end of the Archichlamydeae ("apetalous" and "polypetalous" forms). The Cornaceae are further disturbed by the removal of certain genera from it to the lower cohort of Myrtales. Still more striking changes are suggested for entire families. Thus, the Plumbaginaceae, formerly associated with Primulaceae, are shifted into the neighbourhood of the Goosefoot tribe; the Cucurbitaceae are elevated into an independent cohort, which is allied to the Parietales among the lower Dicotyledons rather than with its former associates of the Composite tribe; and the Salvadoraceae are transferred from the Gentian cohort to that of the Maple allies (Sapindales). Interesting as these changes are to the biological botanist, it is too much to expect that the systematists will forthwith re-arrange their herbarium collections on the new Engler plan! The classification of the Thallophytes—"Algae," "Fungi," Lichens—has been thoroughly revised and brought into accord with the remarkable results of recent researches on the relationships of this vast group.

THE FORMATION OF LOESS.—The deposits of "loess," or fine yellowish sandy clay, found in various parts of the world and often covering large areas, have given rise to much discussion and controversy among geologists. The genesis of loess has been attributed to the action of rivers, glaciers and the wind, by different writers. Shimek (*Proc. Iowa Acad.*) combats the glacial and fluviatile theories of loess formation, and emphasizes the importance of the action of vegetation in catching the wind-blown dust which formed the loess, imbedded in which are shells of herbivorous molluscs. It would appear, therefore, that the origin of loess may be accounted for by wind-action, coupled with the growth of dust and sand-binding plants, though in most cases the plants themselves can no longer be recognised in the deposits.

PHYSIOLOGY OF ORCHID FLOWERS.—Extensive researches have recently been made by Fitting (*Zeitscht. f. Bot.*) on the effects of pollination and other factors on the flowers of Orchids. In his second paper Fitting summarises the effects induced by normal pollination. In all cases investigated the ovary showed the usual lengthening of its life, with accompanying enlargement, and the formation of chlorophyll. The gynostegium (stigma and column) usually showed no striking change in the case of native European species, but in the majority of tropical Orchids the gynostegium swelled, became green, and had its normal life-period extended. Great variety was seen in the effects of pollination on the perianth. In most European species little change was observed beyond slight shortening of the life-period, but this shortening was very marked in *Cattleya*, and so on, the perianth

either closing or changing in colour in withering. In several cases the life-period of the perianth was lengthened, and frequently the perianth became green, or swollen up, or closed. Fitting also experimented with the active chemical substances extracted from the pollen, with killed pollen, and pollen from foreign species. He found that the changes set up in the perianth and gynostegium—that is in parts other than the ovary itself—could be induced by the substances extracted from the pollen. These interesting observations certainly appear to open up a new field of research in connection with pollination and its "secondary" effects on the parts surrounding the fertilised ovary, and they also raise important questions concerning the action of chemical stimuli on the processes of development.

A REMARKABLE LIVERWORT.—In 1849 there appeared in the "Posthumous Papers" of William Griffith, the famous botanist and traveller in Asia, a description of a Liverwort discovered by him and named *Monoselenium tenerum*. This plant was subsequently lost sight of, and Griffith's description neglected, but recently Professor Goebel received from Canton a tea-plant, sent to the Botanic Garden, Munich, and on preserving the soil that arrived with the tea-plant (which, by the way, had perished on its journey) and watering it, he obtained a number of Mosses and other plants, and among them was the Liverwort. *Monoselenium* was very briefly and incompletely described by Griffith, but from Goebel's thorough investigation (*Flora*, *1910*), it appears that this is one of the most remarkable Liverworts known. As is well known to students of the Liverworts, or Hepaticae, the two largest divisions of the group—Marchantiales and Jungermanniales—are sharply distinguished from each other by the structure of the thallus, which has air-chambers and pores in the former group and none in the thalloid species of the latter, though this distinction is not absolute, some Marchantiales having degenerate chambers. In *Monoselenium*, however, we have a plant showing the characteristic sexual receptacles (antheridiophores and archegoniophores) of the *Marchantia* type, combined with otherwise extremely primitive features of structure in both the thallus and the spore-fruit. The thallus shows no trace whatever of air-chambers, and in the capsule there are no spirally-thickened elaters, but only short sterile cells mingled with the spores. That is to say, this remarkable plant combines a variety of characters which have hitherto been regarded as distinctive of several different groups of Liverworts. One of its most surprising features is the fact that though the sexual receptacles are of the complex *Marchantia* type, having numerous growing-points from which the sexual organs are formed, they are seated on the upper surface of the thallus, instead of proceeding from the apex of a branch. The re-discovery and full investigation of this curious type will undoubtedly lead to changes in the current views regarding the relationships of the Liverworts and in the classification of the group.

ANTS AND SEED DISPERSAL.—In 1906, Sernander published a paper on "myrmecochorous" plants, *i.e.* plants whose seeds are adapted for dispersal by the agency of ants, to which the attention of botanists in this country was drawn by Prof. Weiss (*New Phytologist*, 1908). That the seeds of certain plants, *e.g.* violet, cow-wheat, greater celandine, may be dispersed by ants was already known, but Sernander studied a large number of "myrmecochorous" plants and investigated the matter more fully. The attraction which the seeds of these plants have for ants he attributes to the food, largely of an oily nature, which practically all these fruits and seeds provide in a more or less accessible form. He also made careful observations and experiments, and proceeded to classify the various adaptations for ant dispersal. In the majority of cases, the seeds are provided externally with definite food-bodies, or "elaiosomes" (oil-bodies) in the form of appendages of the seed-coat. To this type belong, for instance, violet, bluebell, woodrush, mignonette, fumitory; while in other cases, *e.g.* garlic, the seed-coat is simply impregnated with oil. Most of the one-hundred and twenty plants described by Sernander are meadow and woodland plants, and many show various other adaptations for dispersal besides that due to ants. He watched ants carrying seeds for great distances, and calculated that an enormous number of seeds must be transported in this way in the course of say eighty favourable days each year. In many, if not most, cases the seeds would be carried to the ants' nests, around which he often found the seeds thrown out with the food-bodies bitten off, but many of the seeds were left on the way, especially along paths regularly used by the ants.

Professor Weiss investigated the distribution of the gorse along roadsides and over disused cart-tracks on some moors in England, and suggested that ants probably dispersed this plant, the seeds of which have a brightly-coloured food-body, and thus caused the spreading of gorse bushes along more or less definite lines. Last year (*New Phytologist*), he describes observations and experiments on the lines indicated by Sernander. He placed seeds on tracks along which ants were passing to and from their nests, and found that while the seeds of various other plants were left untouched, those of gorse were rapidly removed. When an ant stopped to examine a gorse seed, it quickly found the bright orange food-body and began to gnaw and bite it, eventually carrying off the seed bodily, holding on by the soft and fleshy food-body. Similar observations were made with the seeds of the broom, which have a food-body like that of gorse. This remarkable method of seed-dispersal has already thrown light on some problems in the distribution of plants, and it will doubtless lead to further interesting results in connexion with Plant Ecology.

AN ABNORMAL LABIATE FLOWER.—An interesting series of abnormal pistils, occurring in plants of the woundwort, *Stachys sylvatica*, has been described recently by Bartlett (*New Phyt.*). A single plant was examined, which showed progressive modification of the pistils, increasing in extent towards the top of the plant. The changes were observed to have taken place generally in the following order:—(*a*) the ovary was much enlarged, especially in length, and the style was correspondingly shortened and very hairy; (*b*) the ovary was represented by two leaf-like hairy carpels, usually united by their edges for rather more than half their length; (*c*) the floral axis produced at its tip one or more flower-buds, the carpels being either of the same structure as before, or becoming to a greater or less degree aborted, and at the same time there was a tendency for the internode between stamens and pistil to become elongated. All these monstrous flowers showed abortion of the ovules. The "phyllody" or leaf-like development of the pistil affords an instance in which a monstrosity throws light on the nature of a structure, for the replacement of the pistil by two leaves furnishes additional evidence that, although the ovary in Labiates is divided into four chambers, the pistil consists of only two carpels, a point which can also be ascertained by tracing its development. A similar abnormality was found by Masters in a species of *Anchusa*, belonging to the Borage order, in which the pistil has the same structure as in the Labiate order.

THE BUTTERWORT.—Although relatively simple in its mechanism, the Butterwort (*Pinguicula*) is one of the most remarkable of the insectivorous plants, our knowledge of which is due to Darwin's classical work. Darwin pointed out that the Butterwort catches the leaves and seeds of plants, in addition to insects, on its sticky leaves, causing seeds to lose their power of germination, and apparently, therefore, deriving part of its nutrition from vegetable matter. The writer has made some experiments with the two species of Butterwort which grow in the bogs of Hampshire—the common *P. vulgaris* and the much rarer *P. lusitanica*—and has found that the plants thrive well when supplied solely with vegetable food in the form of leaves, slices of fresh tissues of various kinds, and seeds. When moist Bog-moss (*Sphagnum*) leaves are placed on the Butterwort leaf, the green cells of the *Sphagnum* soon become disorganised, while the gland-cells of the Butterwort show the same changes that occur when the plant is supplied with insects. The Butterwort should,

XUM

therefore, perhaps be described as "omnivorous" rather than "carnivorous," as it is not only capable of digesting vegetables, but the latter probably form, in natural conditions, a by no

From a photograph by H. Gunnery.

The Common Butterwort.

means insignificant proportion of its food. The accompanying illustration of the Common Butterwort is from a photograph by Mr. H. Gunnery, The Laboratory, Acomb, York.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (Oxon)., F.I.C.

NATURAL VEGETABLE VARNISHES. — Numerous plants contain juices which darken by oxidation on exposure to the air, and some of these find useful application in the arts. Thus the lacquers of China and Japan are prepared from the natural varnishes yielded by different species of *Rhus*, while the Indian marking nut, *Semecarpus anacardium*, contains a yellowish fluid which produces so permanent a stain on linen or paper that it is employed as a marking ink.

Cashew Nut.

Another member of the family, *Anacardium occidentale*, produces the fruit commonly known as the Cashew Nut, which also contains a juice that gives a dark brown stain on exposure to air, but, unlike the juice of the Indian marking nut, does not become black. Experiments made by the present writer have shown that the brown oil in this nut dissolves in potassium hydroxide solution, and combines with lead to form a red salt. This is probably a compound of the reddish yellow oil separated by Staedeler in 1847 and termed *anacardic acid*.

Like all these natural varnishes, or inks, the Cashew nut contains an active principle which produces an irritation of the skin, and the fumes obtained on roasting have a still more pronounced effect, which in the case of the cashew nut, is attributed to an active principle termed *cardol* ($C_{21}H_{30}O_2$). In the case of the *poison ivy*, (*Rhus toxicodendion*) of North America, which is closely allied to the plants producing the Chinese and Japanese lacquers, the juice of the leaves will raise a blister on the skin within forty-eight hours, and even the vapours emitted by the plant, especially at night, may produce eruptions on the skins of peculiarly sensitive people.

One of the most interesting of these natural vegetable varnishes is that derived from *Coriaria thymifolia* and *C. myrtifolia*. The former is known in New Granada as *chauci* or the "ink-plant," owing to the fact that its red juice rapidly becomes black after exposure, and gives so permanent a stain upon paper that it can be used as an ink without special preparation. According to Johnson (*Universal Cyclopaedia*. New York, 1894) all the early documents in Spanish South America were written with the juice of this plant. It also grows in New Zealand, where, too, it is known as the "ink-plant."

The oxidation of the juices of plants of the Rhus family has been shown to be brought about by a special enzyme or *oxidase*, and it is extremely probable that a similar agency accelerates the combination of the atmospheric oxygen with special compounds in the juices of the other varnish-producing plants. This, however, has yet to be proved.

Coriaria myrtifolia.

The "Ink-Plant."

"SHERARDISING" OF IRON AND STEEL.—In the process of coating iron and steel with a fine layer of zinc, technically termed "sherardising," the articles are heated in a closed vessel with zinc dust. The resulting product is extremely resistant to the action of air and moisture, and chains treated in this way have been exposed to the air in constant use for seven years without becoming rusty. The conditions for successfully carrying out the process have recently been investigated by Mr. J. W. Hinchley (Faraday Soc., May 31st, 1910), who finds that considerable variations in the duration of treatment and the temperature are permissible, but that it is essential that the zinc dust shall contain not less than a certain proportion of metallic zinc, preferably eighteen per cent. Mr. Hinchley's results do not support the view of Mr. Cowper-Coles that the process consists in the vaporisation of zinc from the zinc dust, and its condensation on the steel or iron; for he finds that no deposit can be obtained at temperatures lower than the melting point of zinc, such as are used in the treatment. In his opinion the coating is composed of an adherent film of iron in "solid solution" in zinc produced by the metallic zinc in the zinc dust acting upon magnetic oxide of iron formed when the iron is heated. When the zinc dust contains an insufficient proportion of metallic zinc a thin black film of reduced iron is formed on the surface of the article instead of the zinc coating.

THE COLOUR OF IRON SLAGS.—It has been asserted that the blue colour of iron slag from the blast furnace is due to the formation of small quantities of ultramarine, but this view is not supported by experiments made by Dr. H. Fleissner (*Chem. Zentralbl.*, 1910, I, 1901). The results obtained show that the black colour of some of these slags is due to the presence of iron oxide or of carbon, or both, in a fine state of division, while the blue slags are formed from the black slags by partial devitrification, which yields a turbid medium

with a black background, so that the substance appears blue by reflected light. As a rule the blue particles were found distributed between the vitreous black portions and the completely devitrified grey substance. They could be produced artificially by slowly cooling heated black slags, which as they became devitrified changed from blue to grey, and finally to stone colour. When examined in thin sections by transmitted light the blue slags appeared yellow or light brown in colour.

ECONOMIC BIOLOGY.

By WALTER E. COLLINGE, M.Sc., F.L.S., F.E.S.

OAT BLIGHT DISEASE.—The influence of symbiosis upon the pathogenicity of micro-organisms is well illustrated in the results obtained by Dr. T. F. Manns in an elaborate investigation upon the Blade Blight Disease of Oats (*Bull. Ohio Agr. Exp. Stat.* No. 210), in which he shows that virulence and viability of one organism (*Pseudomonas avenae*) upon artificial culture media depend greatly upon the association with a second organism (*Bacillus avenae*). Where oats were artificially infected with either organism separately no typical blight resulted, but where the mixture was applied the blight resulted in twelve days.

Incidentally the author shows that aphids are carriers of the disease, and discusses the possibility of overcoming the trouble by the selection and breeding of resistant varieties.

CONIFERS AND PLANT DISEASES.—In an interesting paper on the Oecology of Coniferous Trees (*Annals Botany*, 1910, p. 241), Professor Percy Groom draws attention to the fact that is worthy of note that evergreen Coniferae have a larger number of serious fungus and insect foes than have dicotylous trees in North-Temperate regions. He also draws attention to the fact that complete defoliation, especially if repeated once or twice, of an evergreen conifer by insects, fungi, or other agencies, leads either to the death or serious weakening of the tree; whereas a deciduous dicotylous tree may suffer defoliation regularly each year and continue to exist. In this respect the larch, being deciduous, rather resembles the deciduous dicotyledon, for repeated partial defoliation by the larvae of the Larch Leaf Miner (*Coleophora laricilla*) does not cause its death.

BATS AND MOSQUITOES.—As destroyers of insect life, bats have long been recognized as beneficial mammals. Recently an interesting suggestion has been made by Dr. C. A. R. Campbell, the City Bacteriologist of San Antonio, Texas, who states that he has observed an apparent relationship between the abundance of mosquitoes and bats, and advocates the establishment of roosts or shelters for the bats in order to favour their increase as mosquito destroyers. In substantiation of his claims he quotes a number of instances, and further suggests that the manure obtainable from the bat roosts would not only pay for their care and construction, but would even prove a profitable investment. There is little doubt that, given favourable conditions, bats multiply enormously, and a large number of insectivorous animals of this kind would probably materially reduce the numbers of mosquitoes and other insects.

I have always been under the impression that bats favoured larger insects, such as moths, for their food, but the subject is one that is distinctly worthy of further study.

VARIATION IN WILD PLANTS.—A study of the question of variation in cultivated plants naturally leads to a consideration of this subject in wild plants. Dr. Halstead has recently shown (*13th Ann. Rpt. New Jersey Agric. Exp. Station*, 1910, p. 323) something of the wide variability of some common weeds. Thirteen plants of the dandelion (*Taraxacum taraxacum*) found on the border of a driveway were transplanted to good soil and given clean culture for a season. The leaves from these plants show great range in absolute size, in the amount of expansion and the manner in which the reduction of the surface is effected. Upon the same plant there is sometimes quite a range of forms. It is possible that the smallest and most reduced leaf is from the Red-seeded dandelion (*T. erythrospermum*), or it and some others are hybrids between the two species named.

Similar experiments have been made with the Shepherd's Purse, Mandrake, Mulberry, Catmint, Ox-eye Daisy, and other plants, and most interesting results have been obtained. The whole question is so full of interest that we shall anxiously look forward to further and more detailed reports on the subject.

PRICKLY PEAR.—The prevalence of prickly pear in certain parts of Australia is a serious drawback to the value of immense stretches of agricultural land, and as yet all attempts to extirpate it by a method that is practicable, viz., one not too costly and that may be applied in an extensive manner, have failed. Its economic value in Australia is very small, and there is a considerable amount of trouble in preparing it before it can be utilized for feeding stock. Australians realize that it is a serious pest, and it is therefore exceedingly interesting to learn that the Queensland Department of Agriculture are investigating a disease that attacks the prickly pear, causing it to wither up and decay. I am informed that the disease is due to a scale insect, and that Mr. Tryon, the Government Entomologist, has been despatched to the district where the scale has been found, to make investigations. After all the strenuous efforts that have been made to eradicate this weed, and the disappointing failures, it will be good news indeed if it is found possible to cultivate the particular scale insect, and spread it over the infested country.

GEOLOGY.

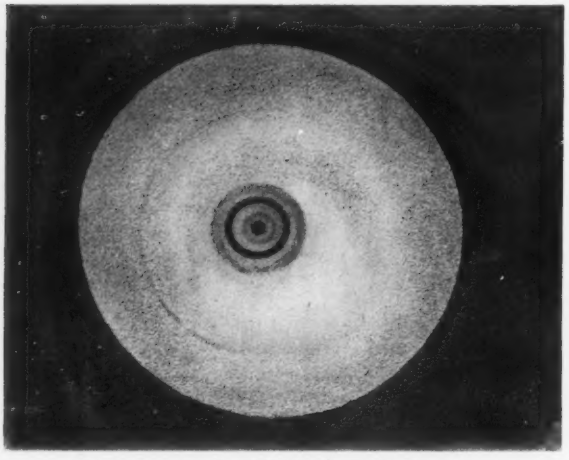
By G. W. TYRRELL, A.R.C.S., F.G.S.

THE WATER SUPPLY OF HAMPSHIRE.—Under this title the Geological Survey has just issued the eighth of its fine series of County Memoirs, dealing with the water-supply derived from underground sources. The veteran Mr. Whitaker is mainly responsible for its compilation; but Dr. Thresh supplies analyses of water, Dr. Mill furnishes a chapter on rainfall, and the descriptions of springs and bournes are mainly derived from the work of the late T. W. Shore. Hampshire is notable for possessing the largest spring supply in the kingdom—that of the Borough of Portsmouth Water Company. This supply is unique amongst large undertakings, and is only supplemented by borings in the spring basins, which really amount to artificial enlargements of the springs. All the other large supplies of the county are from underground sources. The Chalk is the chief water-bearing stratum; and as it is not strictly a permeable rock, the water is mainly distributed by vertical joint-fissures. A large supply may therefore be ensured by cutting across as many fissures as possible. The best method of carrying this out is to drive galleries below the water-table or plane of saturation. After the Chalk, the Lower Greensand supplies the most water. The description of wells and borings is carried out on a topographical basis and occupies the greater part of the book. The great mass of information thus collected should prove of immense service to all concerned in the water-supply of this area. Apart from their intrinsic value, the water-supply memoirs are useful in demonstrating the practical value of the Geological Survey to those people who are apt to demand an immediate and visible return for their money.

SPHERICAL DECOLORIZATION IN RED SANDSTONE.—The peculiar spheres of white rock found in many red sandstones are still to a large extent unexplained. These spheres vary in size from a fraction of an inch to as much as twelve inches in diameter. They are especially common in the Permian red sandstones of the South of Scotland, which have recently been investigated, from the point of view of economic geology, by Mr.R. Boyle in The Transactions of the Geological Society of Glasgow. Chemical analysis has shown

XUM

that the white portions of the rock contain seventy to eighty per cent. less peroxide of iron than the red portions; and the decolorization has usually been ascribed to the reducing effect of solutions derived from the decay of particles of organic matter at the centre of the sphere. But this does not sufficiently explain some cases. Mr. Boyle has figured a beautiful specimen, about ten inches in diameter, from the Ballochmyle quarries. This shows a number of inner rings of a dark greenish colour, which are ascribed to the replacement of ferric oxide by the pale green ferrous silicate. A specimen



Polished slab of Ballochmyle Red Sandstone,
Showing decolourised white sphere with inner rings (diameter about 10 inches).

in the Kelvingrove Museum, Glasgow, here figured, has an agate-like structure due to the development of ringed spheres from several closely contiguous centres of decolorization. The theory of the origin of these spheres from the presence of organic particles seems to need amendment in order to meet the ringed specimens. Mr. Boyle suggests that a species of chemical segregation is responsible for the latter; but the question requires some further research.

GEOLOGY IN THE FIELD.—Part IV. of "*Geology in the Field*," the Jubilee volume of the Geologists' Association, has now been issued, completing a work of great interest and importance to British geologists. The last part contains articles on Northumberland and Durham; the Malvern and Abberley Hills; Shropshire; Charnwood Forest; North and Central Wales; and Cornwall, Devon, and West Somerset. The volume thus completed is a "Geology of England and Wales" compiled on a unique plan. Districts forming more or less complete geological units have been dealt with by authors most closely identified with research in them. The result is a volume which is not only useful to experts, but particularly so to those who study geology in the intervals of a busy professional life. Whatever district they favour for their holidays, they will find in the Jubilee volume a concise and well-written article on the geology of the area, enabling them to dispense with the often laborious and time-consuming work of collecting information from a number of scattered papers, and thus to put their restricted time to the most profitable use.

UPPER KEUPER OF EAST NOTTINGHAMSHIRE.—Some interesting features of the belts of sandstone, locally known as "skerries," in the Keuper Marl of Nottinghamshire, are described by Mr. Bernard Smith, in the *Geological Magazine*. These skerry-belts are usually about six feet thick, and consist of alternations of micaceous sandstone, shale, and marl. Many of the sandstones are highly dolomitic and show a peculiar contorted structure. This is attributed to freshets of water during deposition, producing swirling currents sweeping along heavy loads of sand, and thus tearing up or contorting underlying layers. The formation of skerry-belts is attributed to the following cycle:—

a.—Shallow waters becoming desiccated during a dry period, with deposition of fine marls, and formation of salt crystals in the upper layers.

b.—Influx of fresh water bringing sediment. Salt cystals dissolved out leaving casts. Formation of skerry by successive freshets and current action.

c.—The coarse sediment ultimately failing, laminated shales deposited, finally passing into marls again.

On this theory skerry-belts represent a series of wet spells diversifying the general aridity of the Keuper climate.

METEOROLOGY.

By JOHN A. CURTIS, F.R.MET.SOC.

THE WEATHER OF JULY.—The weather of July, 1910, was, in most parts of the United Kingdom, cold, dull, and rainy, and the month must be classed as unsettled and unseasonable. The continuance of cold winds, with the absence of bright sunshine, were such as to cause anxiety to agriculturalists. July in this respect was like June, and in the summer season of seven weeks from June 5th to July 23rd, there were in England, S.E., only two weeks of unusual warmth, but four weeks of unusual cold; four weeks with heavy rainfall, and only two of light rainfall; one week unusually sunny, but four weeks when the sunshine was unusually deficient. In Scotland, however, the conditions were more favourable, especially in the north and west, where the temperature was higher, the sunshine more abundant and the rainfall less than the average.

During the opening days of the month the shade temperature in the British Isles nowhere reached 70°, while the minimum in many places fell below 50°, and at Cullompton in North Devon it was as low as 45°. The next week showed some improvement, for readings up to 76° were reported. This reading, 76°, was recorded at Killarney, but many stations had 70° or upwards as a maximum. The night temperatures continued to range low, and in many places readings failed to reach 40°, the lowest reported being 37° at Markree Castle, Sligo. At the same station the thermometer exposed on the grass fell to freezing point, while at Sheffield and at Hereford thermometers similarly exposed gave readings of 30°, or 2° below freezing. The Rainfall over the week was only slightly above the average, but the amount of Sunshine was greatly in defect as a rule, although in parts of Scotland and in Ireland excesses were registered. The distribution of Sunshine was abnormal, and Northern Stations enjoyed much longer duration than the "Sunny South." Thus Douglas, in the Isle of Man, reported a total duration of Sunshine of seventy-four hours for the week, or sixty-three per cent. of the possible duration, while Margate got only 21·6 hours, or nineteen per cent. Llandudno also had 61·4 hours for the week (fifty-three per cent.), while Geldeston, near Beccles, reported only 10·4 hours (nine per cent.).

The week ended July 16th again showed some improvement in the temperature, which rose to 81° at Rothesay, and at Newton Rigg, in Cumberland, on the 13th, although in the Channel Islands the maximum was only 73°, and at Scilly only 67°.

Frost at four feet above the ground was reported at Balmoral on the 11th, where the minimum was 31°. At West Linton, near Edinburgh, the minimum was 39°, but at no other stations in the United Kingdom besides those mentioned were temperatures of less than 40° reported from sheltered instruments. From thermometers exposed on the grass, however, readings approaching the freezing point were recorded at several stations. Thus Buxton had 35°, Llangammarch Wells 34°, and Sheffield and Newton Rigg 33°. At Balmoral the reading on the grass

was as low as 29°. The week was dry, the highest district average of rainy-days being two, and at a large number of stations no rain at all was reported. Sunshine was in excess on the whole, the exceptions being the eastern parts of England and the English Channel. Again the differences between individual stations were large. Thus Blackpool reported 96·2 hours of sunshine for the week, or eighty-three per cent. of its possible duration, while Skegness had but 15·6 hours, or fourteen per cent., and Scarborough only 13·3 hours or twelve per cent. At Dublin, in the Phoenix Park, the duration of sunshine was 91·8 hours (eighty per cent.), while at Cromer, usually a sunny station, there was only 2·2 hours registered, or two per cent. In the extreme north, Balta Sound, in the Shetlands, enjoyed sunshine for 63·5 hours, or fifty per cent., while in the extreme south, Guernsey reported 35·7 hours or only thirty-two per cent.

The week ended July 23rd was disappointingly cold, wet and dull. The highest temperature reported at any station in the United Kingdom was only 76° (at Hereford on the 21st) and at many of the stations the maximum did not reach 70°. In the Channel Islands 66° was the highest observed and at Scilly the maximum was only 63°. The lowest temperature reported from a sheltered thermometer was 38°, at Newton Rigg, on the 19th, but at several other stations the minimum was as low as 40°.

At Newton Rigg the thermometer on the grass fell to 31°, or 1° below freezing point. The *range* of temperature was in places very small; thus, at Plymouth the difference between the highest temperature of the week and the lowest was but 11° (66°−55°), while at Jersey it was only 10° (66°−56°).

Rainfall was in excess in all parts except Scotland, E., the Midland Counties, and England, S.E., where it was a little below the average. The total for the week exceeded an inch in many places, and at Geldeston the total was 1·70 inches. On the 20th falls of over an inch were reported over a large area in the N.W. of England, the largest measurements being 1·53 inches at Lancaster, and 1·31 inches at Stonyhurst.

For Bright Sunshine the highest district value recorded was 41 hours (35 per cent.) in Scotland, W., and the lowest 17 hours (14 per cent.) in Scotland, E. At individual stations the highest record was 55·4 hours at Douglas, or not quite half (49 per cent.) of the possible duration, while the lowest was 9·4 hours (8 per cent.) at Crathes, near Aberdeen.

During the period under review the mean temperature of the sea around our coasts was generally lower than in the corresponding period of last year, in places by as much as 5° and 6°. At Margate, the sea temperature ranged between 59° and 61°, the mean remaining between 60°·0 and 60°·6. At Eastbourne, the range was from 58° to 62° and the mean varied from 59°·7 to 60°·7.

At the Royal Observatory, at Greenwich, the highest Shade Temperature reported from July 1st to 23rd was 73°·2 on the 21st, while the lowest was 47°·9 on the 19th. In the Sun the black bulb thermometer registered as high as 139°·7 on the 12th, the shade maximum on the same day being only 71°·0. On two days, 9th and 18th, the shade maximum did not exceed 58°·0. The minimum on the grass did not fall below 40°·0 on any day. The heaviest rainfall was on the 18th, when 0·73 inch was measured, but upwards of half-an-inch fell also on the 2nd (0·55 inch), and on the 3rd (0·61 inch).

There were three days on which no bright sunshine was recorded, and the highest amount recorded on any one day was only 8·7 hours, on the 19th. On only five days during the period under review did the duration of sunshine amount to six hours or upwards.

METEOROLOGICAL OBSERVATORIES.—On July 1st, an important modification of the official meteorological service came into operation, for on that day the observatories at Kew, and at Eskdalemuir, Dumfriesshire, which have hitherto been under the control of the National Physical Laboratory, were transferred to the Meteorological Committee, by whom they will be administered in future.

For many years the Kew Observatory at Richmond has been in receipt of £400 per annum from the Meteorological Office, in connection with the maintenance there of a First Order Meteorological Station, but it has been felt that while this work should be continued it would be of advantage to bring the experimental and observational work, both in Meteorology and in Geophysics, closer together than has been possible hitherto, and therefore, by arrangements recently concluded between the Lords Commissioners of H.M. Treasury, the Royal Society, the National Physical Laboratory, and the Meteorological Committee, the transfer of both the observatories under the N.P.L., Kew and Eskdalemuir, has been provided for.

In the conduct of the administration of the observatories the Director of the Meteorological Office will have the assistance of an advisory Committee, the Gassiot Committee, appointed by the Royal Society to administer the funds of the Gassiot Trust, representing an endowment of £10,000, vested in the Royal Society in 1871, by Mr. J. P. Gassiot for the support of the work of the Kew Observatory. Under the advice of the Gassiot Committee the appointments of Dr. Charles Chree, F.R.S., as Superintendent of the Kew Observatory, and of Mr. G. W. Walker, M.A., of Eskdalemuir Observatory, have been continued by the Meteorological Committee. Dr. Chree has further been appointed as Assistant Director of Observatories for the Meteorological Office. Mr. J. E. Cullum remains Superintendent of the Valencia Observatory.

The work of testing instruments now carried on at Kew Observatory by the National Physical Laboratory will be transferred to Teddington as soon as the necessary arrangements can be made. It is understood, however, that the well-known K.O. mark will be retained by the Laboratory for use with those classes of instruments which have hitherto been tested at Kew.

MICROSCOPY.

We have pleasure in announcing that in future the Microscopy Column will be conducted by MR. A. W. SHEPPARD, F.R.M.S., *the Honorary Editor of the Journal of the Quekett Microscopical Club. He will have the assistance of the following microscopists, whose names have appeared previously at the head of this column.*

ARTHUR C. BANFIELD. ARTHUR EARLAND.
JAMES BURTON. RICHARD T. LEWIS, F.R.M.S.
THE REV. E. W. BOWELL, M.A. CHAS. F. ROUSSELET, F.R.M.S.
CHARLES H. CAFFYN. D. J. SCOURFIELD, F.R.M.S.
C. D. SOAR, F.R.M.S.

A USEFUL ELECTRIC LAMP FOR MICROSCOPICAL PURPOSES.—Some good friends of mine and fellow members of the Quekett Club have expressed great interest in a small electric lamp which I use during the gossip nights of that Club, and a short description of it may be of interest to other microscopical workers in general.

The lamp is mainly intended to provide incident light in conjunction with the Zeiss Greenough binocular, a form of stand which I use very much. The lamp is carried by one of Leitz's dissecting lens holders, and is contained in a short tube, about an inch and one-eighth in diameter. It is provided at one end with a collar of smaller diameter which fits the sprung ring of the lens holder.

The actual lamp is an Osram eight volt, of the same type that is used in motor car head lamps, and in shape it resembles an ordinary glass funnel familiar to chemical workers. The sloping sides of the lamp are silvered on the outside, the effect of which is to form a kind of rough focus of the lamp filament on a small and finely ground glass disc contained in the short tube in front of the lamp.

In my own home I run it from an eight volt Lithanode accumulator of thirty ampére hours capacity, which normally lasts me for a period of about three weeks.

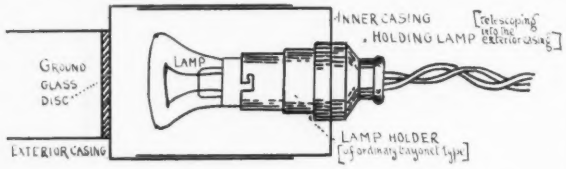
As the accumulator is rather heavy to carry about, at the meetings of the Quekett Club I use the lamp on the two-hundred volt circuit, with an ordinary incandescent lamp of suitable capacity in series with it, as shown in the illustration. The candle-power of the lamp is approximately twelve, and

XUM

gives quite an intense illumination. For low powers it is used at a distance of about two inches from the object; the incidence of the light is easily varied by the suitable adjustment of the stand. Magnifications of seventy to a hundred diameters necessitate the lamp being brought quite close to the object, which can readily be done, as the light is well shielded and does not radiate any heat.

As the type of stand with which it is principally used does not admit of the usual sub-stage arrangements for dark-ground illumination, a very close approximation can be obtained by using the lamp underneath the stage and letting the light fall on the object at a sharp angle, in such a manner that the direct rays cannot enter the objectives. This gives a splendid illumination for the usual class of dark-ground object—Polyzoa and so on, to about sixty diameters.

The lamp will also provide a very good illumination for an



Plan of an Electric Lamp for Microscopical purposes.

ordinary microscope in conjunction with a bull's eye, provided that very high powers are not required. It is not much use for any power higher than a sixth.

I have also used it with a vertical illuminator with great success, which, however, necessitates a small diaphragm immediately in front of the ground glass disc with an aperture about one-eighth of an inch in diameter.

Those microscopists who are fond of making things for themselves will find that a lamp of this description is easily made, used and maintained, and for the purpose for which it was mainly designed—that is, as a ready means of providing incident light—it is ideal.

To those who have current laid on to the house its cost would not exceed thirty shillings including the stand, as the accumulator is unnecessary in such a case.

ARTHUR C. BANFIELD.

The Electric Lamp ready for use with an ordinary Incandescent Lamp in series with it.

EMBRYONIC RADULA OF LIMNAEA INVOLUTA.—*Limnaea involuta* is an Irish freshwater snail of very great rarity, and it is understood that visits from collectors are not altogether welcomed in the locality where it lives. Attempts have from time to time been made to degrade it to the rank of a mere variety of the common *L. pereger*, but its specific reputation is in fact undamaged. Some little time ago I had the good fortune to receive from an Irish correspondent some partly developed eggs of this species, and from one of these the accompanying figure of the embryonic radula was drawn. The unci are clearly differentiated into three types, the distinction between the admedians and externals being shown by a somewhat sudden drop in the size of the basal-plates. The cones throughout are subpectinate in arrangement; in later stages the admedians become squared and bifid, and the central becomes almost simple. (A figure will be found in the *Irish Naturalist*, Vol. XVII, plate 2.) The primitive pectinate symmetry has in later stages given place to a triangulate and quadrate symmetry of a different form; in other words, these teeth (unci) begin by looking like a row of little combs, and as they grow they become transformed into a row of little pyramids mounted on squares; but the change hardly affects the externals, and becomes less and less as we move away from the centre. This pectination of the unci is found in the externals of most land and freshwater Gasteropods, except Zonitidae, Limacidae, and Testacellidae; and where it is found it is also more pronounced in the younger stages. It does not seem that the externals are called much into active use in the adult snail, though it may be supposed that the pectinate form of radula (which may perhaps be used as a strainer rather than a rasper) may suit the animal in its initial stages, especially if it be a water-snail. We should therefore be inclined to regard those species which exhibit more pectination in their radulae as more ancient forms. In the case before us the second admedian shows three larger cusps instead of two, and the form of its basalplate is rounded and not squared; this has also been observed in other species, though in *Limnaea* the normal adult admedian has two main cusps. This appearance therefore suggests the inference, which on other grounds is probable, that the additional rows

Part of the Embryonic Radula of *Limnaea involuta*.

of unci arise between the second admedian and the first external, or are formed by doubling of the external rows; and it also supports the opinion that the first admedian is the most constant uncus in the whole transverse row. We also conclude that as the externals preserve the earliest type in any given radula, it is to them we should look for an indication of the family to which the species belongs; and it may be said that generally the admedians are characteristic of the genus, the exceptions being doubtless due to the great fluctuations that obtain in the value of generic divisions. In many cases the central uncus is the one which most definitely determines the species, when allied forms are compared; there is, however, a very much better way of using the radula to decide such questions, as will hereafter appear. The central uncus in our embryonic *involuta* is remarkable for having pectinations which appear to decide its homology with a single pleural uncus; and in consequence of this it becomes, in these primitive forms, asymmetrical. The asymmetry often persists in *involuta* and the allied lacustrine species, while it is very frequent in *glabra*, and almost the rule in *truncatula*.

When secondary symmetry is achieved in the centrals, which happens as a rule in the majority of radulae, it is also the rule for the central uncus to become simple or trifid. A remarkable exception occurs in *Planorbis*, where it is normally bifid, rarely trifid: and I have just observed a bifid central row, exactly like that of a *Planorbis* in an abnormal specimen of an Irish lacustrine *Limnaea*. The specimen is normal in other respects, and I regard the bifid abnormality as additional evidence of the antiquity of these lacustrine forms.

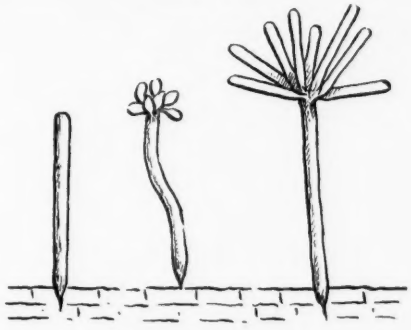
The preparation of embryonic radulae is a less difficult matter than might be supposed; it is effected most conveniently with the help of a compound microscope fitted with Porro prisms.

E. W. BOWELL.

ON MOUNTING MITES.—The best preservative I have found for Mites is a glycerine solution prepared in the following manner.—Ten parts pure glycerine, ten parts distilled water and three parts citric acid dissolved in distilled water. This preservative was given by Dr. Koenike in the journal of the Plon Biological Station some time ago for the Hydrachnidae, but I have found it suit nearly all the Acarina. This solution is no trouble, as the mites can be placed in it alive. They die at once and contract their limbs into anything but a satisfactory condition for microscopical examination, but in a few days the solution permeates the interior of the mite, and the limbs and body are again extended into a condition which will allow of proper examination. The soft-skinned species gradually lose their colour, in most cases only retaining it in the chitinous parts. The hard-skinned mites nearly always retain their colour, and in some cases the colour is not only retained but rendered more brilliant and transparent than in life. When properly cleaned they can be mounted direct into the same solution, or in glycerine jelly, or the glycerine can be gradually dissolved out in several changes of weak spirit, and they may be mounted into balsam in the usual way. The balsam I think suits the hard-skinned best, and the glycerine jelly the soft ones. I have some mounted for me by Mr. Taverner in the jelly, and they are as good now as when this was done some five or six years ago.

CHAS. D. SOAR.

SCIADIUM ARBUSCULA.—A singular and interesting micro-alga, called in the older books *Sciadium arbuscula*, but by West, *Ophiocytium Arbuscula*, is sometimes found as an epiphyte in fresh water pools and lakes. It does not appear to be very common, but, being small, is probably often overlooked. In June it occurred in one of the ponds in Epping Forest in surprising quantity. The rootlets of



Sciadium arbuscula.

duckweed, the finely cut leaves of water crowfoot and similar bodies were covered with a dense growth of it. The plant consists of a single cylindrical tubular cell, varying considerably in length—average from 70 to 100 μ., and 3 to 5 μ. in width. It is attached by a short thin stalk, and is filled with pale green protoplasm. Its reproduction is unique. The protoplasm divides into gonidia, eight being the typical number, but there are often more; these pass up to the top of the tube, which then opens, and they attach themselves to the rim, and there develop. They gradually increase in size, particularly in length, till they resemble the parent, forming an umbel at the top of the parent stem, which is then empty and hyaline. When this generation is developed equally and at regular intervals, as is frequently the case, the whole forms a symmetrical and exceedingly pretty object. Under favourable circumstances the same process is repeated by the second generation, and occasionally even a fourth generation arises in the same manner, making an apparently complex, but, when its origin is understood, really a simple figure of great elegance. Not infrequently specimens may be found with considerably more than eight rays in the second generation, but it is seldom that all of them produce a third, and usually only one or two are successful in maturing a fourth. The gonidia produced by the latter do not attach themselves to the parent, but swim away to become established in a fresh place. I have sketched at A a single plant, at B the commencement of the second generation, and at C the same when it is nearly mature.

J.B.

ON COUNTING AND MEASUREMENTS.—Many beautiful instruments have been devised to facilitate these often necessary operations, but there are few cases that cannot be met by the employment of simple methods. In examining the radulae of snails it is often requisite to count the number of rows, and to do this with the eye alone is extremely fatiguing. A mechanical stage enables the count to be made, each row being reckoned as it passes a cross line placed within the focal length of the top lens of the ocular, or as it passes out of the field of view. It may be somewhat difficult to keep the row under consideration at the right part of the field; this is rendered easier by those mechanical stages which have the two movements arranged to be operated by coaxial milled heads. If the object can itself be rotated on the mechanical stage, the same result is obtained. It is less convenient for this purpose that the stage itself should rotate. And there may be imperfections in the preparation, or in the degree of flatness of the glass, which render any actual movement of the object undesirable. One has recourse, therefore, to some plan for introducing a pointer, capable of movement from outside, into the field of view. Some of the oculars provided with pointers for demonstration purposes will answer quite well, though it is inconvenient to have the outside lever so near to the eye. A very fine method is to employ a special ocular with a web which may be made to travel across the field of view; but equally good results (for the purpose of mere counting) may be obtained by the following simple method: a needle point is set up five or six inches in front of the mirror, and by focussing the condenser and moving the mirror the image of this needle point is brought into the field of view. This image may now be used as a pointer, either by moving the needle itself or by moving the mirror, the former method being preferable, and necessary when a limited source of light is used. I find it convenient to mount the needle axially upon a little stand used for holding lantern plates while their edges are being bound. Slight refocussing of the condenser may be required as the image passes to the outer parts of the field; this might be obviated by making the needle travel in the particular curve which would make it continuously equidistant from the condenser axis, and a special stand could be devised to do this; but practically I have not found anything of the sort necessary. An achromatic condenser naturally gives a much clearer and more satisfactory image of the needle point, thus again justifying its use in a working microscope; for when much work has to be done we naturally prefer arrangements that cause as little strain as possible. The plan just described, with the achromatic condenser, makes the counting of rows a positive pleasure, while nothing elaborate is needed, and the preparation need not be disturbed on the stage. Quite a low power will generally suffice; a good two-inch is here most valuable. For the making of actual measurements an accessory instrument of great value is the slide rule; a table of logarithms could of course be used to the same purpose if a slide rule be not at hand. The occasion for this accessory arises from the fact that when the tube length is adjusted to the best optical advantage it rarely happens that the divisions on the scale of an ocular micrometer are equal to a whole number of divisions of the stage micrometer, and hence they represent units of appreciably different value. We therefore set down in a column the readings obtained from the ocular micrometer; then determine the ratio between these intervals and those of the stage micrometer by substituting the latter for the object; this ratio being obtained for the particular combination of objective and ocular in use, the true values can at once be set down opposite to the readings by means of the slide rule. It is to be desired that some manufacturer would put upon the market a scale for dropping into the ocular, having much finer divisions than those at present obtainable;

XUM

the actual size of the divisions is quite immaterial, so long as they extend right across the field of view, and have each fifth and tenth clearly marked. This subject has been introduced in view of the fact that the making of exact measurements will probably become, in the near future, a much more important branch of microscopy than it is at present, and it is eminently a branch in which non-professional microscopists might take an interest, and do valuable work. The two scales needed can be purchased for ten shillings.

E. W. BOWELL.

THE ROYAL MICROSCOPICAL SOCIETY.—On June 15th the President, Professor Arthur J. Thomson, M.A., exhibited two slides of a rare and very interesting synaptid, sent to the Society by Mr. M. J. Allan, of Geelong, by whom it was thought to be new, but Professor C. Vaney, of Lyons, had identified it as *Trochodota dunedinensis* originally discovered and named by Professor Jeffery Parker. Messrs. Flatters and Garnett sent for exhibition a copper water bath for glycerine jelly mounting, a black and white tile for dissecting, framed in mahogany with drawer for instruments, a cheap form of cabinet for holding slides, and a cloth-covered drawer unit containing twelve trays, holding six slides each, all readily accessible. Some photo-micrographs of Grayson's rulings of one thousand to ninety thousand lines per inch taken by himself, were sent for exhibition by Mr. Nelson. The one thousand to ten thousand bands were magnified by three hundred, the ninety thousand band was magnified by two thousand, and there were two enlargements of this by six thousand and eight thousand.

The President read a paper "On some Alcyonarians collected by Sir E. Shackleton's Antarctic Expedition. They were collected by Mr. James Murray, at Cape Royds, and some of the specimens were only obtained after cutting through fifteen feet of ice. There were only four species in the whole collection, all of which had been found before. They were *Clavularia rosea*, Studer, *Clavularia chuni*, Kuekenthal, *Alcyonium paessleri*, May, and *Ceratoisis delicatula* Hickson.

Dr. Hebb read a paper by Mr. E. M. Nelson on an "Apparatus for increasing the power of an Achromatic Condenser." The object of the author was to improve the action of an achromatic condenser when used for giving dark-ground illumination for the observation of bacilli and other minute objects under high powers. The apparatus consists of a hollow truncated cone of glass, polished on all its surfaces, and formed, in fact, an annular prism. Parallel rays of light entering the annulus at the base were, by two internal reflections, caused to emerge at the upper surface, through a much smaller annulus, the proportion of the areas in the example given being about 2·4 to 1, and the light would be increased in intensity in that proportion. The paper was criticised by Mr. Conrady, who contended that Mr. Nelson's proposition was directly contrary to the second law of thermodynamics.

A "Note on the Use of the Mercury-Vapour Lamp in observing the Rings and Brushes in Crystals," by Mr. E. B. Stringer, was read, and in illustration Mr. C. L. Curties exhibited for the author a crystal of calcite, polarised, under a microscope, which could be illuminated by the Mercury-Vapour Lamp, or a Nernst Electric Lamp, by merely turning the mirror towards one source of light or the other, so that the superior result obtained by the Mercury-Vapour Lamp was readily observed.

A proposed new fine adjustment for the body and substage of microscopes by Mr. E. B. Millar-Williams was described and illustrated by drawings. The opinion was expressed that it would be a costly arrangement, but no opinion could be offered on its merits from the drawings; it would be necessary to be able to test it in actual working.

THE QUEKETT MICROSCOPICAL CLUB.—On June 28, Mr. A. C. Banfield exhibited and described a sliding nosepiece, designed to do away with the irritating floating shadow noticed in low-power stereo-photo-micrographs when strongly lighted opaque objects are dealt with, and the object is moved to secure the stereoscopic effect. Transparencies showing the advantage of the new method were exhibited.

Mr. D. Bryce read a very important paper on "A new classification of the Bdelloid Rotifera." Such a paper does not lend itself to profitable abstracting. It will be published in full in the next (November) issue of the Club's *Journal*.

Mr. E. M. Nelson, F.R.M.S., communicated a paper, which was read by the Honorary Secretary, on "*Navicula rhomboides* and allied forms." The first part of the paper dealt with the identity of the old Amician test, and after showing that it could neither be *N. rhomboides* nor a *Grammatophora*, the author said he agreed with Dr. Karop, who, in a paper read before the Club on March 15th, 1895, expressed the opinion that Professor Amici had no one particular test, and that the test as known in America differed from that used here. Mr. Nelson's paper went on to describe the differences between several forms in his possession labelled *rhomboides*, that which he takes as the true *rhomboides* having an average length of '0036 inch, which is 4·9 times its breadth, the transverse striae counting seventy-two to seventy-three in $\frac{1}{10000}$ inch. Four varieties of *rhomboides* were described. So long as the minute variations noted are expressed in words, it is almost impossible to estimate, out of the many differing peculiarities or features a diatom may possess, the resultant of the whole of them. It was shown that if the fineness of the transverse striation is multiplied by the length-breadth ratio a constant, thirty-five, is obtained. Examples were given. If, then, we divide the number of the transverse striae by the length-breadth ratio, we shall get a number that will be the numerical index for the variety. The paper proceeds to apply the rule practically to certain species in a well-known "type plate."

Mr. A. Earland read a paper describing a number of Arctic types of Foraminifera obtained from the North Sea by dredgings from the S.S. Goldseeker, employed by the International North Sea Commission. He considers that the material examined tends strongly to prove the truth of the geological theory as to the origin of the North Sea, and that until late Tertiary times it had no connection with the warm Atlantic, such as that now afforded by the English Channel. Warm water forms are only now slowly making their way by the warm Atlantic currents between the mainland and Orkneys and Shetlands into the North Sea. Many very interesting forms, and a new species of *Cornuspira* were exhibited.

PHOTOGRAPHY—PURE AND APPLIED.

By CHAPMAN JONES, F.C.S., F.I.C.

INTENSIFICATION WITH MERCURY AND FERROUS OXALATE.—The prominence recently given to this method by the publication of the results of my further investigations concerning it, has caused many inquiries to be made as to the method by which it can best be carried out, as the process is not described in many of the commoner text books. The solutions required are three. (1) A saturated solution of mercuric chloride to which is added a little hydrochloric acid to prevent the gelatine itself, or any alkaline matter that it may contain, from combining with or causing a deposit of mercury salt. The amount of strong hydrochloric added may be 3 c.c. to the litre or half a dram to the pint. If this causes reticulation of the gelatine, the amount of acid may be smaller, but it ought not to be necessary to reduce it. This is the ordinary solution used for other methods of mercurial intensification, and has been in common use almost as long as gelatine plates. (2) A saturated solution of neutral potassium oxalate. This salt dissolves very copiously in water. This and the first solution are conveniently made up in considerable bulk as they do not deteriorate on keeping. (3) A saturated solution of ferrous sulphate. This will not keep as ordinarily bottled for longer than a day or two,

though the solid will keep indefinitely. As only a small quantity of the ferrous sulphate solution is required, it is conveniently prepared shortly before it is wanted, by taking a bulk of the solid salt equal to about half the bulk of solution required, and grinding it with about an equal measure of water in a mortar. More water may be added as necessary, but after a thorough grinding there should remain some of the solid undissolved. The solution can be poured off, or filtered if necessary.

The negative must be thoroughly washed. If there is doubt as to this, it should be washed in a flat dish for about an hour, changing the water every ten minutes or so. This is better than so called "running water" managed in any practical way of which I know. The negative is placed in the mercury solution and allowed to remain until nearly bleached through, when it is thoroughly washed. This washing is best done in a flat dish, changing the water occasionally. The time necessary depends on circumstances. The thin film of an autochrome plate is washed in a very few minutes, while an ordinary negative may require more than an hour; one hour and a half is a good average. The necessary quantity of potassium oxalate solution is measured out, and to it is added one sixth of its bulk of the ferrous sulphate solution, and the mixture is at once poured over the bleached and washed negative. As this solution removes the chlorine from the silver mercurous chloride (that is, the material of which the bleached image consists) the image darkens. It is not difficult to see when the change is complete by looking at the underside of the plate, though the image is never of that jet black that ammonia gives, and the colour is somewhat modified by the iron solution, which is red when fresh and inclined to be greenish in those parts where it is most exhausted. The iron solution is of no further use; therefore, when the change is complete it is thrown away, and the negative is well washed to get thoroughly rid of it. If hard water has been used, there may be a deposit on the surface of the negative, or a slight opalescence in the gelatine due to the lime salts in the water. This can be got rid of by putting the negative into weak hydrocholoric acid (about one to ten of water) until it dissolves away.

Although the method may seem tedious in the description of it, it is really very simple. Its unique advantages I have already described. It is not a method to be recommended to a beginner in photography, but then a beginner's negatives rarely have any value other than an educative one for the maker of them.

DETAIL IN PRINTS.—It is generally, if not always, desirable to make clear the utmost of detail in photographic prints made for technical purposes. But too often in a photo-micrograph or a spectrum photograph the detail in the darkest, as well as in the lightest parts, although visible on the negative, is lost in the print, because the character of its surface breaks up the light that passes through it and prevents one from clearly seeing *into* the film. A perfectly smooth surface obviates these difficulties, giving a surface through which the light can pass, without being scattered, to the image beneath, and from which it is reflected without suffering loss from irregularity. The result is much the same as if the image were imbedded in a sheet of polished glass, or in no medium at all. The object of glazing prints is to get rid of surface irregularities with the degradation of the character and brilliancy of the image that they cause. This matter merits much more attention than it receives, being unduly neglected because of the difficulty of getting a glass-like surface on prints. The method in principle is simple enough. The print is allowed to dry with its face in actual (or optical) contact with a smooth surface, preferably of glass, as that has the best surface of all, though polished celluloid or enamelled (ferrotype) iron may be used. The dry print when separated has a surface that is the exact counterpart of the surface against which it has dried. But the practical difficulty is that however carefully the glass, or the celluloid, or the ferrotype iron has been prepared, the prints are liable in parts to stick too tight or to come away too soon, so that the effect is irregular and the print often torn or otherwise spoiled, except, of course, in the hands of those who are constantly doing such work. It is, therefore, with peculiar satisfaction that we welcome the "Ensign" glazing solution.

"ENSIGN" GLAZING SOLUTION.—This solution, issued by Messrs. Houghton, so far as my experience goes, does away with all the difficulties of sticking too firmly to the plate or prematurely separating from it. Even an ordinary dirty piece of glass, just washed and dried with a duster, when rubbed over with a little of the glazing solution, gave perfect results when damp gelatine prints were squeegeed upon it. If the prints did not actually fall off when dry, they were detached perfectly and evenly by a mere touch, and presented an unbroken surface as brilliant as the glass itself. It is the very thing for those who only occasionally need to glaze a print.

TABLOID PREPARATIONS.—Messrs. Burroughs Wellcome & Co., send booklets in French descriptive of their exhibits in the Brussels International Exhibition, including many details with regard to their well-known "Tabloid" and "Soloid" preparations and example prints of their effects in photographic prints, the staining of sections for photo-micrography, and so on. Other booklets summarise the work that has been done in the firm's chemical and physiological research laboratories, established by Mr. Henry S. Wellcome in 1896. A considerable part of these booklets refers to photographic preparations.

PHYSICS.

By W. D. EGGAR, M.A.

CELESTIAL MECHANICS.—On the night of Sunday, July 10th, there passed away the last of the protagonists in the memorable discovery of Neptune. Johann Galle, the astronomer who on the nights of September 23rd and 24th, 1846, looked at a portion of the heavens suggested to him by Le Verrier, and found there an eighth-magnitude star with a proper motion, was born on June 9th, 1812, and was therefore ninety-eight years of age at his death. Before Galle's discovery Challis had been searching for the planet with the Cambridge equatorial, and had actually observed it on the 4th and 12th of August, 1846, without recognising it as a member of our system, through lack of a proper star-map. Nowadays the laborious work of the observer would be replaced by the photographic plate on which Neptune and other planets and comets would leave their own unmistakeable trail. In this year in which the first great prophetic application of Newton's Principia has been for the third time verified by the reappearance of Halley's Comet, it will not disturb the *entente cordiale* to recall the controversy which raged as to the rival claims of Adams and Le Verrier to the credit of discovering Neptune. When the facts became known, they were recognised as conferring equal merit on both men, and the planet was happily named after the god of the region which separates their native countries.

In a time when the experimental method of teaching physics is universal, it may well be considered in what state the study of Mechanics would have been by now, supposing that Newton's Laws of Motion had never received their magnificent celestial demonstration in the observational work of a long line of practical astronomers, from Tycho to the old man who died the other day. Would Newton's Second Law be twisted round from the form "Change of momentum is proportional to the force" into "Force *is* rate of change of momentum"? Should we have escaped the controversy between the poundal and the slugg? (Suggested question for temporizing examiner —"What is the weight of a slugg in poundals"?) In short, what would mechanics be now, what would natural philosophy be now, if the exactitude of the movements of the celestial bodies had not drawn so many pure mathematicians into the domain of physics? The science of electricity was wrested from the votaries of "action at a distance" by the genius of Faraday, who regarded mathematics as a servant, perhaps as

XUM

an upper servant, declining to receive orders from a mere physicist, but certainly not as a master. The great mathematicians have done noble service to physics; but some of their band have been inclined to regard with disdain any experimental verification of their laws in which any less accuracy was attainable than that shown by the movements of Halley's Comet. We have, therefore, two schools of mechanics, the school for engineers, and the school for astronomers. The engineers may well join in the general tribute of respect to one who was an astronomer indeed.

THE PASSAGE OF LIFE FROM PLANET TO PLANET.—Professor Svante Arrhenius has lately revived the theory of the passage of life from planet to planet, perchance from one solar system to another, basing his speculations on the presumed speed at which particles of cosmic dust may travel, and on the proved powers of resistance to extreme cold which are possessed by the spores of some forms of vegetable life. He points out (*The Life and the Universe*, Vol. II., p. 255) that the possibility for living organisms to wander, by the aid of the radiation pressure, from the planet of one solar system to another belonging to another solar system, is conditioned by the low temperature of space. Low temperature can so strongly check and diminish the vital activity that life may be sustained for millions of years. . . . . Paul and Prall took vegetative organisms (not spores) of Staphylococci in the dried state. At ordinary temperature half of the bacteria perished within three days. But their vitality did not decrease noticeably when they were kept for four months at the temperature of liquid air. That (observes Arrhenius) is a very beautiful proof of the remarkable preserving influence of intense cold upon the germinal power. Thus although, as far as we can judge, spontaneous generation is no longer possible on the Earth, and probably even no longer possible under the similar conditions of previous ages, this phenomenon might conceivably take place elsewhere in the Universe, under materially different physical and chemical conditions. From the spot or from the spots where spontaneous generation was possible, life might have spread over to the rest of the habitable bodies of the Universe. . . . A demurrer to this seductive theory was entered by M. Paul Becquerel in a paper read before the meeting of the Paris Academie des Sciences (July 4th), in which he points out that the bactericidal effect of the ultra violet rays from incandescent stars has been neglected by Prof. Arrhenius. M. Becquerel recognises that the combined effect of extreme dryness and of extreme cold considerably increases the powers of resistance to the destructive action of ultra violet rays, but it does not make them invulnerable. He has exposed spores in a vacuum and under conditions of extreme cold to the action of ultra violet light, and their life is completely destroyed in a few hours. This destructive action of the ultra violet light would seem therefore to be universal. But if that is the case, then, seeing that the celestial spaces about our planet are ceaselessly traversed by light which is rich in ultra violet radiations, there is a very large probability that all spores passing through these dangerous zones would be rapidly destroyed. Interplanetary space is sterilising and sterilised.

SOUND WAVES IN STILL AIR.—It is a familiar experience, even of unpractised observers, that there are states of the atmosphere in which sound travels in very different ways. For example, on bright sunny days distant sounds are seldom heard, while a popular belief affirms that rainy weather is indicated when the sound of distant bells is clearly audible. The audibility does not depend, however, on the dryness or humidity of the air, but on its homogeneity. If the air is perfectly homogeneous then the effect of a horizontal air current, which is usually feeble near the ground and strong higher up, is to bend the rays of sound out of their straight line directions. If the observer is to windward of a sound (such as the sound of a bell), the vibrations may be carried over his head; if to leeward they are brought down to him. If the observer is in a calm stratum of air with the wind blowing strongly above him—as happens sometimes in early morning—he may hear nothing at all if he is to windward of the sound, but a more intense sound if he is to leeward. Ordinarily however the air is not homogeneous, but is a mixture of warm and cold, or dry and moist masses. The rays of sound, therefore, having to pass through many alternations of rarer and denser air, become reflected and refracted at each transmission, losing in intensity each time. So that the range of a bell is always less in sunny than in cloudy weather, always less during the day than at night, always less over land than sea. During still quiet nights, beneath clouds, the atmosphere is usually most homogeneous, and, if there is no wind, sounds are heard to the greatest distance. Tyndall supplemented these obvious facts by supposing that there exist in the atmosphere large masses of air which differ in density and temperature from their surroundings, and which act as reflectors or resonators of sound waves. Some experiments recently made by Mr. W. V. Carr reproduce on a small scale the conditions of Tyndall's theory. Mr. Carr placed near a large tuning fork, (such as is used in lecture experiments), and in the plane of vibration of both its branches, an open beaker. The tuning fork gave five hundred and twelve vibrations a second, and the beaker was five centimetres in diameter, and fifteen centimetres in depth. The sound of the tuning fork was reinforced by the resonance of thecolumn of air in the beaker. Then Carr placed at right angles to the plane of the first beaker another similar one. The sounds were then practically extinguished, thanks to interference, because the vibrations of the air at the entrance to the two beakers were of discordant phase. When, however, the mouth of one of the beakers was closed with a piece of cardboard, the conditions of interference were destroyed, and the sound reappeared. The same results were obtained by placing underneath one of the flagons a flame. The warm column of air as it rose served the same purpose as the cardboard: it reflected the sound waves.

LIGHT AND VEGETATION.—M. Raoul Combes has endeavoured to determine, at the various stages of plant development, from germination to grain formation, the amount of light which is most favourable for the differing physiologic phenomena. The phenomena studied were:—the production of vegetable matter, chlorophyll assimilation, tuberination, flowering, fruit formation, fruit maturing, adaptation to light, determination of sex. M. Combes found that the best light for any specific phenomenon in a given plant differed during the life of the plant according to the stage reached. Generally speaking we might say that a feeble light is best for the plant during its earlier stages, and that as the plant grows older it needs stronger and stronger light. Strong or intense light provokes in vegetation the accumulation of nutritive matter in the green parts of the plant, and is therefore favourable to the formation of fruits and rhizomes; while feeble light determines on the other hand the utilisation of nutritive substances, and accelerates in consequence the production of the plant organs, such as leaves and shoots.

ZOOLOGY.

By PROFESSOR J. ARTHUR THOMSON, M.A.

CHEESE MAGGOTS.—There is a fly called *Piophila* that lays its eggs in cheese, and there are people who prefer their cheese with these maggots thrown in. G. Alessandrini has been studying the larvae recently, and feeding dogs with them. They can pass right through the alimentary canal (both of man and dog) without being the worse, but the canal is apt to be the worse for them, for they scratch the delicate mucous membrane with their minute oral hooks. Alessandrini put some for sixteen hours in seventy per cent. alcohol and others for thirty hours in petroleum, but they survived all right. Living creatures often impress us with their delicacy, but often, also, with their toughness.

A GENTLE MOSQUITO.—Everyone knows how some ants milk Aphides, but Edward Jacobson tells of a mosquito

milking an ant. For that is what it comes to. The mosquito frequents certain trees in Java on which the ants *(Cremastogaster difermis)* go to and fro. It hails a passing ant and strokes the head with quick movements of its fore-legs and antennae, probably tickling, perhaps massaging, the ant. In any case the ant emits a drop of juice, which the mosquito sucks up. Then the ant goes on its way, a pathetic instance of naturally good abilities spoilt by an exaggerated state-socialism. The mosquito has been named *Harpagomyia splendens* by de Meijere, who points out that the creature cannot bite. Jacobson found two other Diptera in Java which seem also to have learned how to tap the ants. Like the mosquito they have discovered a deep wisdom in the advice "Go to the ant, thou sluggard."

GLANDS OF CATERPILLARS.—Many naturalists have studied the silk-glands which open in connection with the labium of caterpillars. The raw material of the silk is formed in the living matter (both nucleoplasm and cytoplasm) of the secretory cells; it filters into the cavity of the gland, and after sundry transformations issues in the form of the familiar threads of silk. Each thread shows a homogeneous hyaline core of silk proper, and a delicate fatty sheath which can be removed by alkalis or by washing. Associated with the silk-glands there are accessory organs—the glands of Lyonnet—which secrete a liquid or slightly viscid material. According to Bordas, one of the last investigators of this much-discussed subject, the product of the accessory glands serves to unite the threads of silk, and possibly acts on them chemically as well as physically, helping them to harden rapidly. Bordas has also studied the mandibular glands, which are usually present in caterpillars, and finds that their secretion is mainly defensive, though in some cases digestive as well. In most of the numerous types of caterpillar that he studied Bordas found thoracic glands, similar to those in the larva of the Puss Moth, which secrete formic acid.

INDIAN FRESHWATER CRABS.—The Indian Potamonidae, recently catalogued by Dr. Alcock, illustrate well how a particular type may adjust itself to a great diversity of environment. They are typical inhabitants of fresh water, but a few species can also exist quite well on the one hand in brackish water, and on the other in damp jungle. "They are found in ponds, lakes, streams, rivers, and marshes; and though they flourish most at low or inconsiderable levels in the tropics, they extend into the warmer temperate regions, and are also quite common at considerable elevations in the torrid zone."

In illustration of diversity of habitat, Dr. Alcock refers to *Paratelphusa spinigera*, a very common species in the swamps of Lower Bengal. "In the rainy season it can be seen in any Calcutta tank, often reposing on the bank, half-immersed in the water: in the cold season it may be found in the jheels in swarms, half-buried in the mud: in the hot season, where the surface-waters dry up, it digs deep burrows to get down to the ground water. The same species, *P. spinigera*, on the one hand, ascends the Ganges and Jumna as far as Hardwar and Saharanpur, and the Jhelum valley to an elevation of two thousand feet, and, on the other hand, does not object to the brackish water of the Gangetic delta." In the neighbourhood of Darjeeling, at elevations of five thousand to seven thousand feet, at least two species of these crabs may be met with, and in river pools in Baluchistan, at an elevation of over six thousand feet, where the winter cold may be intense, varieties of *Potamon fluviatile* can find a living.

Another interesting general point concerns the development. The eggs are comparatively large, and are not extremely numerous in a batch. They are carried under the tail as in marine crabs, but they seem to be hatched not as zoaeas, but in a much more advanced stage. The young stay in the mother's brood-pouch until they have attained the adult form and a considerable size.

ASSOCIATIONS OF FREE-SWIMMING DECAPODS.—The study of definite associations among animals has still a long way to go to overtake the study of plant-associations. There are a few notes in this connection in Mr. Stanley Kemp's recent account of the free-swimming Decapod Crustaceans of the Irish coast. Thus *Typton spongicola* is found living within Monaxonid sponges, such as *Desmacidon; Richardina spinicincta*, the only representative of its family in British waters, is probably restricted to the areas peopled by the Hexactinellid sponge, *Pheronema*, and its Indian Ocean congener occurs inside the glass-rope sponge; the rare *Leontocaris lar* occurs among Antipatharians and colonies of the beautiful coral, *Lophohelia*.

NOTICES.

POSTS IN THE PATENT OFFICE.—An Open Competitive Examination for not fewer than seven situations as Assistant Examiner in the Patent Office will be held by the Civil Service Commissioners in September next. The Examination will commence on the 26th of the month, and forms of application for admission to it are now ready for issue and may be obtained on request addressed by letter to the Secretary, Civil Service Commission, Burlington Gardens, London, W.

LITERARY INTELLIGENCE.—Dr. Bernard Hollander, whose book on *Hypnotism and Suggestion* has just been published, has yet another book in the press, which Messrs. Rebman, Ltd., will shortly bring out. Its title is *Mental Symptoms of Brain-Disease: An Aid to the Surgical Treatment of Insanity*, and it will have a preface by Dr. Jules Morel, Belgian State Commissioner in Lunacy.

Messrs. Rebman also announce a new book by Dr. Berry Hart, of Edinburgh entitled *Some Phases of Heredity and Evolution*. In this, special attention is given to Mendelism and a new theory of evolution is described.

METEOROLOGICAL INSTRUMENTS AND TELESCOPES.—We have before us Section IV of Messrs. Aitchison and Co's. catalogue which consists of nearly one hundred pages on which are illustrated and described the varied types of barometers, thermometers, rain gauges and other instruments for which the firm in question is justly celebrated.

Inserted in the catalogue is a leaflet dealing with astronomical telescopes which are British made and being supplied by Messrs. Aitchison & Co. at reasonable prices, are very suitable for amateurs.

THE GREEN BOOK OF LONDON SOCIETY.—We welcome the appearance of the *Green Book of London Society*, which has been edited by Mr. Douglas Sladen and Mr. W. Wigmore. Messrs. J. Whitaker & Sons are the publishers, and it is the first annual book of reference published in the new reign. It contains all the new court and official appointments, which will not be found in *Whitaker's Almanac* before the edition of 1911 appears, and it obviates the issue of a supplement to the well known book of reference in question. An immense amount of time and trouble has been spent upon the directory of British titles, to which two hundred and forty-eight pages are devoted, as well as to the list of peers, peeresses and official personages which occupies one hundred and ten pages. Science is treated briefly on pages 450 and 451, and we are given a list of eminent lecturers, authors, painters, actors, and so on. Altogether the book will be found exceedingly useful, for much information may be more readily obtained from it than from any other books of reference.

REVIEWS.

ASTRONOMY.

Astronomy, a Handy Manual for Students and others.—By F. W. DYSON, F.R.S. 7¼-in. × 5-in. 247 pages. 95 diagrams and illustrations.

(J. M. Dent & Sons. Price 2/6 net.)

The Amateur Astronomer.—By GIDEON RIEGLER. Translated by G. A. CLARKE. 6¾-in. × 4¼-in. 320 pages. 112 illustrations.

(T. Fisher Unwin. Price 3/6 net.)

An Easy and Concise Guide to the Starry Heavens.—By D. M'EWAN. 8½-in. × 5½-in. 148 pages. 25 illustrations.

(Kegan Paul & Co., Ltd. Price 5/-)

We bracket these three volumes together because there is a certain family likeness between them, and they jointly and separately testify to the spread of a taste for astronomical learning which has become so marked a feature of the last twenty-five years.

Mr. Dyson's book is written in an easy, pleasant style, which without, perhaps, being very profound, is clear and intelligible. Its great drawback is the seeming lack of plan and method in the sequence of the subjects. They come upon the reader in no definite order; and when one reads one section, the next section is not what you expect will follow, but something else. His book is therefore rather a handy book of reference than a book gradually to unfold learning in due course to a student. Looked at with this reservation it is a book which will be very useful to many readers.

Mr. Riegler's book is open to very much the same criticism: only more so; for it has no adequate beginning and seems put together on no definite plan. It opens with three introductory chapters, the second of which deals with the choice of an observing station, and the third with instrumental equipments. This last-named chapter is very defective, for it contains several lettered diagrams on the optical principles of telescopes, but is devoid of all reference in the text to the numerous letters attached to the diagrams. It is a mockery to submit information in this fashion, and this remark applies to such a sentence as the following:—The magnitude of the field of view "can be ascertained practically by marking the two points which limit the field of view and then measuring the angular distance between them." On the next following page appears what can only be called a useless allusion to spherical aberration. Again who ever heard the polar axis of an equatorial called: the "hour axis"? The polar axis carries an "hour circle"; but that is quite a different matter. On p. 43 we are told that "the offices of popular Astronomical periodicals can often negociate sales and purchases" of instruments. This is news; and a duty which we doubt if any office of a periodical has ever been known to carry out. Does the author mean that periodicals contain advertisements of instruments? That, of course, is true, but is quite a different matter from his statement. In many places the translator's English is very weak. For instance, to say that the accuracy of the work done in the great observatories is a "bye-word" sounds rather queer; as also is such a sentence as the following: "The unsuspected rise which Astronomy has taken during the last decade," nor did we know before that "a large number of amateur astronomers" make the observation of variable stars their special study. On the contrary, it has been made quite a recent matter of complaint at the British Astronomical Association that so few amateurs pay any attention to variable stars. The chapters on the constellations and particular stars and clusters are useful, but a disproportionate amount of space is given to the moon, to the detriment of the planets and comets.

The author of the third book on our list, which we may call the Umbrella Book, has struck out for himself an entirely new line, and has shown considerable cleverness and care in doing so. The main idea which underlies his scheme, is the obvious difficulty of teaching young students the geography (so to speak) of star-land by means of globes carrying the stars on a *convex* surface, whilst the stars when we actually look at them appear to us on the *concave* vault of heaven. Mr. M'Ewan, therefore, makes a special form of umbrella, divided into eight segments, with the principal stars marked on the inside, so that when it is opened the concave inside corresponds as near as may be to the concave vault of heaven. The segments of the umbrella are reproduced in engravings which appear in the text of the accompanying book, and various tables and descriptive paragraphs serve to help an inexperienced student to identify and learn the names of the various constellations and the stars included in them. The whole scheme is most original and ingenious, and we strongly recommend our readers to invest in one of Mr. M'Ewan's umbrellas and in the book that goes with them.

Solar Eclipse Expedition to Flint Island, January 3rd, 1908. By F. K. MCCLEAN, F.R.A.S., and others. 10-in. × 12½-in. 18 pages. 15 Plates.

(Privately printed.)

This is a volume which, whilst deserving the highest commendation for its intrinsic interest, and for the way in which it has been put together, yet hardly lends itself to being reviewed in the usual way. The text comprises only 18 pages, but the great feature is the series of 15 highly interesting plates, exceedingly well executed, though not differing very materially from the ordinary run of eclipse expedition records.

CHEMISTRY.

Radium.—By JOHN PERCEVAL LORD. 4⅞-in × 7¼-in. 103 pages. Illustrated.

(Harding Bros. & Co. Price 2/6 net.)

Anyone who wishes for information given in a non-technical way upon the origin, properties and uses of radium cannot do better than obtain a copy of this little book, which is now entering on its third edition. It is clearly written in simple language, and has been brought thoroughly up to date. The section dealing with the medical applications of radium will be found particularly interesting—the more so since it is not always easy for the layman to obtain an impartial account of this branch of the subject.

Practical Chemistry.—By JAMES BRUCE & HARRY HARPER. 4¾-in. × 7-in. 240 pages. 62 figures.

(Macmillan & Co., Ltd. Price 2/6.)

Apart from its obvious use for examination purposes, this little manual will be found a sufficient guide to those who, having acquired some slight knowledge of the principles of chemistry, are taking up practical work. It is so clearly arranged that it could well be used by a student working without the direction of a teacher. It includes descriptions of general methods and apparatus, the preparation of pure inorganic and organic substances, and the qualitative and quantitative analysis of typical compounds. The directions are clear and concise, and the diagrams of apparatus are all that is needed in this direction.

XUM

The Calculations of General Chemistry.—By WILLIAM J. HALE, Ph. D. 5¼-in.×7½-in. 174 pages.

(George Bell & Sons. Price 4/6.)

This is essentially an Arithmetic of Chemistry, and should prove useful to students who wish to render themselves familiar with the calculations required in the practical applications of the science. It deals fully with such subjects as specific gravity, physical properties of gases, the law of proportion and the derivation of chemical formulae; and the value of the book is increased by the series of problems with which each section concludes.

Metallography.—By CECIL H. DESCH, D.Sc., (Lond.) Ph. D. (Würzb). 5¼-in.×7½-in. 429 pages. 108 figures.

(Longmans, Green & Co. Price 9/-.)

The investigation by means of the microscope of the structure of metals and alloys in relation to their physical properties has now attained the position of demanding its own literature, and the present work is intended to fill the gap. The whole subject is ably discussed with full reference to the work of other chemists, most of which has hitherto been only accessible in scattered scientific publications. As in other books in this series indications are given of the directions in which research may lead to fruitful results in the future, and this adds to the value of the work. It is one that should be in the library of every metallurgical chemist and engineer.

Metallography applied to Siderurgic Products.—By HUMBERT SAVOIA. 4¼-in.×6¼-in. 179 pages. 94 illustrations.

(E. & F. N. Spon, Ltd. Price 4/6 net.)

This little book will not only serve as an introduction to the study of metallography, but will also be found of value by all who have to make use of iron or steel (with which substances it is mainly concerned). Although written from the practical point of view, it also deals with the history and theory of the subject, and gives full references to the original papers in each section. It is well translated from the Italian, and amply illustrated with excellent photo-micrographs showing the effects of variations of composition upon the structure of the metals.

The Constants of Nature.—Part V. A Recalculation of the Atomic Weights. Third Edition. Revised and Enlarged. By FRANK W. CLARKE, LL.D., D.Sc. 6½-in. × 9¾-in. 548 pages.

(Smithsonian Institution.)

An immense amount of work has been involved in the recalculation and averaging of the results obtained all over the world in the determination of the atomic weights of the elements, and the values here given represent the nearest approach to the real values possible as yet. For ordinary analytical processes the series of atomic weights annually published by an International Committee are quite sufficient, but for research work in physical chemistry this publication of the Smithsonian Institution will prove an invaluable work of reference.

Radio-Chemistry.—By A. T. CAMERON, M.A., B.Sc. 5¼-in.×7¼-in. 174 pages. 15 figures.

(J. M. Dent & Sons, Ltd. Price 2/6 net.)

The phenomena of radio-activity are here dealt with from the point of view of the chemist rather than that of the physicist, physical details being introduced only where absolutely necessary. The book will, therefore, appeal to the non-physical reader to a greater extent than most treatises on the subject. The discussion of the bearing of recent discoveries upon the transmutation of the elements and of the speculations based upon them will be found full of interest. The methods used in the investigation of radio-active compounds are fully described, and the addition of an excellent bibliography adds to the value of the work as a handbook on radio-chemistry.

GEOLOGY.

An Introduction to Petrology.—By F. P. MENNELL, F.G.S. 5¾-in.×8⅞-in., 204 pages, Illustrated.

(Gerrards, Limited. 8/- net.)

For a text book this work is occasionally highly speculative, but it is open to question whether this is a fault or not. The author explains that it is intended to serve rather as a concise handbook for the working geologist, than as a text book in the ordinary sense of the word. With this end in view he has produced a decidedly fresh and stimulating book, although some of his ideas are rather crude and ill-digested. The practical limitation of the author's experience to South Africa, and his isolation from geological literature, is probably responsible for this. Chapter I deals with general considerations, and is followed by an excellent section on the collection and preparation of material. Chapters III-IX deal with the rock-forming minerals and their characters in thin section. We doubt whether the student will gain much from the chapter on "Phenomena in Polarized Light"; but this is an extraordinarily difficult subject to treat satisfactorily in a limited space and without numerous diagrams. The igneous rocks, to which the lion's share of space is allotted because of their primary importance as the ultimate source of all rocks, are described in Chapters XII-XVII. With regard to classification, an extreme simplification is favoured. The author's views on the origin of igneous rocks are coloured by his intimate acquaintance with the highly granitic area of Rhodesia. The extensive melting-down of all kinds of rocks at great depths to form magmas of approximately granitic composition is advocated, and supported by several ingenious arguments. In consequence the author is rather severe on the current conceptions of petrographical provinces and differentiation, implying, as they do, derivation from originally homogeneous magmas, although he grudgingly admits that differentiation may be a *vera causa* in certain instances. The sedimentary and metamorphic rocks are treated in Chapters XVIII-XX. The remaining three chapters deal with the weathering and chemistry of rocks, and the question of radio-activity in relation to rocks. The latter is an excellent summary of an important subject. There is a full index, and the illustrations are good as a whole, although some of the photo-micrographs were either originally poor, or have suffered in reproduction. We have found no misprints, but on p. 166 the familiar Michel-Lévy is rendered "Michael Levy." We can recommend this book to the petrological student, but he should be cautious in accepting some of Mr. Mennell's theoretical conclusions.

The Miner's Guide.—By F. P. MENNELL, F.G.S., 5-in. × 7½-in. 196 pages. Illustrated.

(Gerrards, Limited. Price 4/- net.)

This little guide is essentially a third edition of the author's Rhodesian Miner's Handbook, and is intended to serve as a practical handbook of mining and mining Geology for prospectors, working miners, and mining men generally. In addition to general geological information and the consideration of ore-deposits, valuable chapters on such subjects as prospecting, and the testing, sampling, and working of ores are given. The book seems to serve its purpose admirably, and the mining man, who is too often woefully ignorant of geology, will be better equipped for his work if he carries this pocket-volume about with him.

Bulletins of the Department of Geology, University of California Publications. Vol. 5. Nos. 21, 26, 27, 28. 7-in.×10-in. Pp. 305-307; 397-403; 405-411; 413-420.

Illustrated. Prices 10c., 10c., 15c., and 10c. respectively.

In Bulletin No. 21, L. Y. Miller describes *Teratornis merriami*, a new genus of raptorial bird from the Quaternary asphalt of the Rancho La Brea beds in southern California.

No. 26, by E. L. Furlong, is devoted to the description of a new aplodont rodent, *Aplodontia Alexandrae*, from the Miocene of the Virgin Valley in North-Western Nevada.

XUM

In No. 27, a primitive flounder, *Evesthes jordani*, is described by J. Z. Gilbert, from the Miocene diatomaceous beds near Lompoc, California.

In No. 28, A. Knopf discusses the probable Tertiary land connection between Asia and North America. The stratigraphical evidence, as far as known, throws little light on the subject, but is so far favourable to terrestrial communication between the two mainlands in Tertiary times, allowing some commingling of faunas.

NATURAL HISTORY.

Science in Modern Life, Vol. IV. Edited by J. R. AINSWORTH DAVIS, M.A. *Botany* (cont.), by J. M. F. DRUMMOND, B.A. *Zoology*, by J. R. AINSWORTH DAVIS, M.A. *Science and the Sea Fisheries*, by J. TRAVIS JENKINS, D.S., Ph.D. 9-in. × 6-in. 235 + IX pages. Illustrated.

(The Gresham Publishing Company, Ltd. Price 6/-.)

Among the admirable volumes of the series none is written with greater care or with more conspicuous capacity for terse expression than this, which comprises a survey by Professor Ainsworth Davis of the history of Zoology, and a summary of the present state of knowledge in animal evolution; as well as the completion of Mr. Drummond's work on Botany, and the increasingly important department of it, Plant Ecology. The arrangement of Mr. Drummond's sections is extremely clear and useful. In his section dealing with the Flowering Plants, for example, he considers first the reproductive structures from the point of view both of plant anatomy and ancestry; and follows with descriptions of plant physiology and mechanism before dealing with the distribution of plants and their economic importance. Some very suggestive paragraphs on plant abnormalities, and on experimental morphology and on the subjects recently touched upon by Francis Darwin in what is described as plant memory, give a rounded completeness to the whole. It would have been out of place, or at any rate out of proportion in a work of this kind, to devote any considerable space to the modern problems and modern speculations on memory as a factor in heredity; but Mr. Drummond considerately points out where the study of this subject can be pursued.

Professor Ainsworth Davis after disposing of the history of Zoological knowledge and theory, first surveys the animal kingdom and classifies it; and then in a series of chapters endeavours to trace the evolution of animals in geological time through the various epochs—Archaean, Cambrian, Ordovician, Silurian, Close of the Primary Epoch, and so on through the Mesozoic and Cainozoic eras. This is a rather dangerous form of speculation, because, though many beautiful series have been traced in the lower orders of animals, especially among the molluscoidea, the problem is too complicated for dogmatism, and nearly every new discovery of fossil remains, especially among the vertebrates, makes more uncertain the origin and descent of the higher forms of life. Nevertheless, as a means of provisional classification there is much to be said for the method, and Professor Davis is to be congratulated on the clearness with which he presents the accumulated knowledge. The volume concludes with three valuable chapters by Dr. Travis Jenkins, Scientific Superintendent of the Lancashire and Western Fisheries Committee, on the international investigations of the food fishes, their migrations and the reason for them.

The Aims and Methods of Nature Study—A Guide for Teachers. By JOHN RENNIE, D.Sc., F.R.S.E. 5-in. × 6-in. 352 pages. 178 figures.

(W. B. Clive. Price 3/6.)

Very many of the volumes on Nature Study which have been produced of recent years for the use, we will not say, benefit, of teachers, while setting forth, at the beginning, the objects and meaning of the teaching which is now known by their title, prove, when one turns over the pages, to be merely "cram books." They contain an array of facts of a more or less scientific nature for the teacher to learn and say to the class. Dr. Rennie in his own first chapter, and with the help of a well considered introduction written by Professor J. Arthur Thomson, not only most clearly defines and explains the aims and methods of Nature Study, but shows upon what conditions and under what circumstances it has and can be made successful. Then follow, in the body of the book, suggestions as to the choosing of topics, as well as the drawing up of schemes of a character suitable to the time of year, to the locality in which his pupils dwell, and, most important, to the bent of the teacher.

It is quite recognised that out-door work must of necessity be more restricted in the town than in the country, but, like one or two advocates of Nature Study have done before him, Dr. Rennie seeks to bring as much of the open air as possible into the classroom by means of specimens, and the recounting of first-hand observations made both by pupils and teachers under the sky. There is so much of true educational value in Dr. Rennie's book that every teacher and parent interested in the proper training of children should read it, and put the principles there laid down into practice forthwith.

The Science of Happiness.—By HENRY SMITH WILLIAMS, M.D., LL.D. 6¼-in. × 9¼-in. 350 pages.

(Harper & Brothers. 7/6 net.)

Well thought out, moderate and preëminently attractive are among the descriptions that must be applied to *The Science of Happiness*. The book has a taking title, and those whom this encourages to glance at the pages within, will, unless wildly heedless of their future, be constrained to read and thereby share the opportunity of profiting mightily. One may be induced to experiment as to whether he may not be devoting an hour too much to sleep, and another who has been forced to adopt sedentary habits may be reminded that the dietary which he came to adopt in his athletic days, can be with advantage modified, a third will find something suggestive in the chapters on "How to see and remember," or "How to think." In the latter the author points out that the man who is "lucky" through a long series of transactions is assuredly the man whose judgment, on the average, is better than that of his fellows. The habitually "unlucky" man is the one who lacks the all-essential elements of common sense. In this connection, Dr. Smith Williams advises the taking of a specific training in some department of experimental science—such as bacteriology, or physics, or chemistry, and he goes on to say:—

> "When, for example, your training in the laboratory has enabled you to take a minute quantity of some chemical and pass it through one process after another, producing it now in solution, now as a salt, now as a fused metal, now as a compound; returning it at last, perhaps after days of manipulation, to its original state—the same in quantity to the thousandth of a grain, as before, nothing more, nothing less. When you have learned to make such a manipulation as this you will have taken a lesson both in accuracy of method and in severe logicality of reasoning from cause to effect, which will be far more valuable as a mental method than any mere knowledge of chemical processes involved in your study. Here, indeed, as I see it, lies the real value of scientific training. The student, who at the end of such manipulation as I have just outlined, finds that his chemical has lost the thousandth of a grain or so, knows that there is no question of "luck" involved in that. He has carelessly spilled a drop or two of one of his solutions, or he has failed to rinse out the last dregs of a beaker."

Under the heading of "Vocation *versus* Avocation," the advantages of a hobby are mentioned, and nature studies are especially recommended. The discussions on "Life Companionship," which deals with the choice of a wife, will prove of great interest to many. To those who have had the advantage of a biological training much that is said will no doubt appear obvious, but they will welcome the way in which matters are brought forward for the benefit of the many. There is an excellent index, and the author is to be congratulated on the possibilities for good which lie in his book.